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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

THE TEA RESEARCH INSTITUTE,
St Coombs, Talawakele,
Ceylon.

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General.—The laboratories of the Institute are situated at St Coombs Estate, Talawakele, and letters and enquiries should be addressed to the Director, Tea Research Institute, Talawakele. Telegraphic address: Research, Talawakele; Telephone: Talawakele 44 (Private Exchange).

It is particularly requested that letters should not be addressed to officers by name. Specimens and other consignments sent by rail should be forwarded to Talawakele Station, c/o Messrs M. Y. Hemachandra & Co., Ltd., Forwarding Agents. *Carriage should be pre-paid.*

Low-country estates should address their correspondence and enquiries to the Low-Country Adviser, T.R.I., "Kalindi," Riverside Road, Ratnapura.

Visitors' Days.—The *second* and *last* Wednesdays in each month have been set aside for Visitors' Days at St Coombs Estate and also at the T.R.I. Sub-Station, Gonakelle Estate, Passara, when it is hoped that those interested will visit the stations.

Guest House.—The house formerly used for guests is now an officer's residence and it is regretted that, for the time being, no Guest House facilities are available. Those visiting the Institute or the Estate on business, who are unable to arrange accommodation in the neighbourhood, should seek the help of the Director.

Publications.—The Tea Quarterly, Bulletins (New Series), Pamphlets, and Annual Reports, published by the Tea Research Institute will be sent free of charge to Superintendents of Ceylon tea estates over ten acres in extent and to estate agencies dealing with Ceylon tea, if they register their names with the Director, Tea Research Institute of Ceylon, St Coombs, Talawakele.

Other persons can obtain the publications of the Institute on application to the Director, the post-free subscription being fifteen rupees per annum for persons resident in Ceylon or India and £1–5–0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs 2.50 or 4*s*. Indian cheques should have four annas added to cover commission.

THE TEA QUARTERLY

Vol. 31 December, 1960 Part 4

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EDITORIAL COMMENT

Organic matter

Mr Ramaswamy has contributed an account of biochemical studies on the organic matter in Ceylon tea soils. Various aspects of soil organic matter are to be considered in several papers at the next T.R.I. Biennial Conference on January 20-21st, 1961. Scientific understanding of the importance of soil organic matter, the quantity and quality of it, in relation to the growth of crops is still far from sure. There is therefore much room for discussion, but above all we must marshal the available facts and avoid plausible assumptions. Mr Ramaswamy's article provides some useful facts, and some surprising data: for instance on the large amounts of mineralisable organic nitrogen present in tea soils, quite apart from the nitrogenous fertiliser we find it pays to add. A much fuller understanding is required of what such facts mean.

Soil has also been called a living medium, and the dead organic matter content is the basis of life for a complex microflora and microfauna. Bacteria, fungi, nematodes, mites and soil insects are amongst the varied life of the soil. Dr Mulder's article, dealing with the influence of the soil microflora upon the incidence of diseases and pests of tea and other crops, is partly speculative, but also gives the facts as far as they are known.

Nitrogen deficiency

The importance of foliage deficiency symptoms as cheap and reliable indicators of plant health has been stressed previously. The note by Drs Visser and Mulder on nitrogen deficiency, with particular reference to clonal plants, will certainly be followed by others on deficiency symptoms, with coloured illustrations. It is important that every planter should be able to recognize the symptoms of various deficiencies; good colour plates are so much more useful for recognition than any amount of written description, but they can never be entirely life-like.

Chemical control of Nettle Grub and Shot-Hole Borer

The article by Mr Cranham and Mr Fernando describes recent work on the control of Nettle Grub, a pest which has been locally serious for a long time. Investigation of the various aspects of the use of insecticides is going ahead, so that when and where we need to use them, it shall, as far as is possible, be an informed use; and, of great importance, so that we do not, in controlling one pest, create others.

Mr A. P. Newton's Letter to the Editor on the subject of dieldrin spraying for Shot-hole Borer should prove of great interest, particularly to mid-country planters. It certainly is so to us, for, in what might aptly be called 'The Sanquhar Experiment', the whole estate is being systematically sprayed with dieldrin as fields are pruned.

Our own trials and investigations are being pursued with vigour, but as yet we do not have sufficient data on certain points to make a general recommendation for the chemical control of Shot-hole Borer. The most important point at issue is the side-effect produced by dieldrin in causing outbreaks of Tea Tortrix caterpillars, due to the interference with the parasite of Tortrix, *Macrocentrus homonae*. Moreover,

it is our duty to study very fully the possible long-term effects of any new practice in the tea industry before we can give it our full backing.

However, without question, the actual chemical control of Shot-hole Borer by dieldrin sprays applied after pruning shows much promise, and we will be glad to give the information we have to any estates that wish to experiment on their own initiative and responsibility.

Spraying methods

On certain crops, mechanization of spraying has developed a great deal in recent years, and efficient distribution of the spray liquid using much lower volumes of water is often achieved by 'air-assisted' spraying, *i.e.* a powerful blast of air breaks up the spray liquid into very fine droplets and also assists in carrying the droplets to the 'target'. Large power-operated machines are simply not practicable in Ceylon tea, but in recent years this type of sprayer has been developed as a shoulder-mounted or knapsack 'mist blower'. Mr Elias in his article describes his experience so far on blister-blight control with these machines. Work is also being carried out by the Tea Research Institute on insecticide application by this method, and reference is made to one field trial in the article on Nettle Grubs.

Mechanized charging of battery knapsack sprayers, on the other hand, has been used in Ceylon for several years. Mr Elias has also recorded experience at St Coombs with one of these charge pumps.

Advertisers in the Tea Quarterly

For a time the T.R.I. tested and approved fungicides for the control of Blister Blight. In 1958, this practice was stopped because of the large number of similar fungicides coming on to the market which were known to be very similar in performance. This leaves us with the unsatisfactory situation that some firms can add the phrase 'Approved by the T.R.I.' to their advertisements, while others—possibly equally good—cannot. The organization of the Institute is not such that it can run a comprehensive Approval Scheme.

In order to resolve this inconsistency, we have asked those firms which have approved products for sale not to use the phrase 'Approved by the T.R.I.' any more. They have agreed to this.

We might refer in this respect to the Rubber Research Institute Quarterly Journal: 'Advertisements are accepted on the understanding that the Institute accepts no responsibility for the claims made therein'. This of course applies equally to machines and materials other than the fungicides. Also, the Institute naturally reserves the right to refuse to publish any advertisement.

Tea Quarterly and Bulletins 1926—1960

The Tea Quarterly has been published since 1928, and with changes in the planting community over that period, it would seem that few people have a full set of all the issues from the beginning. The same applies to Bulletins from 1926—annual reports and others. With some expansion of staff in the T.R.I. we need more complete sets of these publications, and if any planter or company has these, and because of retirement, duplication, or other reason, can offer them for sale, we would be most grateful if they would inform the Editor.

BIOCHEMICAL STUDIES ON THE ORGANIC MATTER IN CEYLON TEA SOILS

M. S. Ramaswamy

This paper deals with investigations of a preliminary nature carried out during the years 1953—1957 on the biochemical aspects of organic matter in Ceylon tea soils. The investigations were generally confined to cultivated soil from St Coombs Estate (elevation 4,500′ AMSL), but the results of experiments on tea soils from other elevations, when they relate to the subject of this article, have also been included.

Studies on the organic-matter status of Ceylon tea soils have so far been mostly confined to the assessment of the total carbon and total nitrogen contents; the results, though useful in many respects, do not indicate the *nature* of the nitrogen in the soil, particularly that fraction of the nitrogen which is mineralised to ammonia, nitrites and nitrates by the soil microbes and is thus made available as plant food. For example, up-country tea soils are very rich in organic nitrogen, but a large part of it appears to be resistant to mineralisation by soil microbes and therefore unavailable as food; the total nitrogen content of these soils does not indicate the immediate fertility of the soil.

The rate and degree of mineralisation by the soil microbes can be studied under controlled laboratory conditions. The results of such experiments may not truly represent the changes that occur under natural conditions in the field, but they do indicate to some extent the fraction of the organic nitrogen susceptible to mineralisation.

It has been shown (Tolhurst, 1956) that organic matter in tea soils in both the low country and the up country is high though variable, whilst it is uniformly low in the mid-country. It is possible that the rate of mineralisation of organic nitrogen in the mid-country soils is equal to if not more rapid than the build up of organic nitrogen from prunings and old leaves from tea and shade trees, etc. On the other hand, in the up-country tea soils there appears to be a highly resistant nitrogen fraction which is difficult to mineralise. In Part I of this article, preliminary studies on the fractionation of organic matter in an up-country tea soil (St Coombs estate), and the susceptibility of these fractions to mineralisation when incorporated into the soil, are reported. In Part II, experiments conducted to evaluate the proportion of the organic nitrogen susceptible to mineralisation in tea and jungle soils from districts at different elevations and with differing climatic conditions are described; studies on the rate and degree of mineralisation of organic nitrogen in up-country tea soils are also included.

PART I.—SOIL ORGANIC MATTER

In the study of the organic matter in Ceylon tea soils, attention has mainly been directed towards the determination of the total carbon content. Even though the amount of soil organic matter can be calculated roughly from the carbon content, the factor used for this purpose has been disputed, since the composition of the organic matter varies widely in different soils. A fractionation study, on the other hand, is likely to be more useful, because it could throw some light on the nature of the resistant and susceptible fractions present in tea soils.

Before attempting the fractionation of the soil organic matter, a method of extraction which will cause the minimum possible changes in its physico-chemical properties must be used; since classical methods involve the use of strong alkali, a study of the milder and neutral reagents was made by Bremner & Lees (1949). A similar approach was made to the extraction of the organic matter from tea soils using both alkaline and neutral reagents. The effect of various regeants on the solubility of the organic nitrogenous compounds in tea soil under two different experimental conditions is given in the following tables (Tables 1 & 2).

TABLE 1.—*Effect of various reagents on the solubility of the organic nitrogen in tea soil*

(St Coombs, Field No. 10, 0–6″ layer) (Results expressed as % total organic nitrogen extracted)

Reagents	Strength of the reagent (M)	Four consecutive washings of 24 hrs duration in a separating funnel		Occasional shaking of the soil with the reagent for 24 hrs Single extraction (Soil sample 1)
		Soil sample 1	Soil sample 2	
potassium dihydrogen orthophosphate (KH_2PO_4)	0.1	5	—	—
di-potassium hydrogen orthophosphate (K_2HPO_4)	0.1	8	—	—
tri-potassium orthophosphate ($K_3PO_4.H_2O$) ...	0.1	28	32	11
potassium pyrophosphate ($K_4P_2O_7$)	0.1	28	50	30
potassium pyrophosphate neutralised with hydrochloric acid	0.1	—	41	21
tri-potassium orthophosphate neutralised with hydrochloric acid	0.1	—	16	5
potassium fluoride ($KF.2H_2O$)	0.5	23	61	28
potassium oxalate $(COOK)_2.H_2O$)	0.2	14	—	—
potassium citrate ($K_3C_6H_5O_7.H_2O$) ...	0.2	16	—	—
sodium DL-tartrate $(CH(OH).COONa)_2$ H_2O)	0.2	11	—	—
potassium hydroxide (KOH)	0.5	24	39	51

TABLE 2.—*Effect of various reagents on the solubility of the organic nitrogen in a tea soil profile*

(St Coombs, Field No. 9). (Results expressed as % total organic nitrogen extracted)

Reagents	Strength of the reagent (M)	Soil profile	
		0—2″	2—6″
potassium pyrophosphate, neutralised with hydrochloric acid	0.1	29	31
potassium fluoride	0.5	50	45
potassium hydroxide	0.5	32	29

Of the various reagents tried, potassium fluoride was found to be the best; apart from being a neutral reagent, the percentage of extraction of organic nitrogen was found to be comparable to, or even greater than, that of potassium hydroxide.

An experiment was next carried out to determine the optimum strength of the potassium fluoride reagent for the maximum extraction of the organic nitrogen. Typical results for one soil sample are presented in Figure 1.

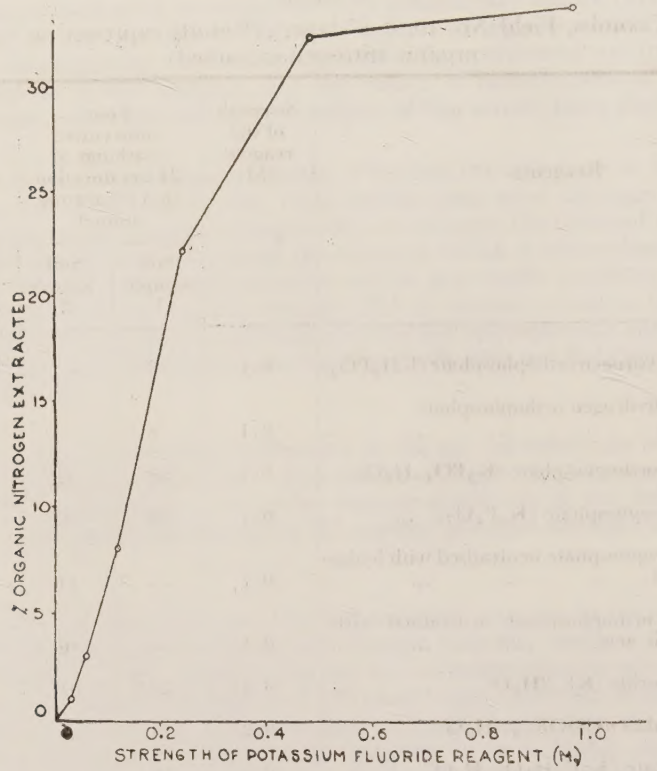


Fig. 1—Extraction of soil organic nitrogen by potassium fluoride reagent.

The optimum strength was found to be about 0.5 M.

The organic matter extracted with the potassium fluoride reagent was next dialysed against distilled water, to remove the inorganic constituents, and it was found that part of the organic nitrogen was also dialysed. The dialysable fraction of the nitrogen represented ammonia, nitrites, nitrates, probably also with amino-acids. Between 8 and 16 per cent of the toal organic nitrogen was found to dialyse. The results are shown in Table 3.

TABLE 3.—*Dialysable fraction of organic nitrogen*

St Coombs Field No.	Profile	Total organic nitrogen		Dialysable organic nitrogen as % total organic nitrogen
		Before dialysis mgs	After dialysis mgs	
8	0—2″	40.0	35.5	11.2
10	0—2″	20.4	17.2	15.7
	2—6″	16.9	15.0	11.2
2	0—2″	16.0	14.8	7.5
	2—6″	12.2	11.2	8.2

The organic matter extract after dialysis was fractionated into humic and fulvic acid fractions by treatment with dilute sulphuric acid to pH 3.0.

The susceptibility to mineralisation of the humic and fulvic acid fractions of the organic matter from St Coombs cultivated soil (Field No. 9, 0—2″ layer) when incorporated with the same soil and incubated at 30° C for 4 weeks (moisture 33%) was estimated. For purposes of comparison similar fractions obtained by the initial extraction of the soil with alkali were also incubated with the soil. The results are shown in Table 4.

TABLE 4.—*Percentage mineralisation of nitrogen in organic matter fractions when incorporated into tea soil.*

(Results expressed as % mineralisation of organic nitrogen).

Organic matter fraction	Organic matter extracted by	
	Potassium hydroxide 0.5M	Potassium fluoride 0.5M
Humic acid	10.7	1.7
Fulvic acid	27.8	62.4

The humic acid fraction obtained by treatment with alkali appeared to be less resistant to mineralisation than that obtained from potassium fluoride. The fulvic acid fraction obtained from alkali treatment, on the other hand, was found to be more resistant to mineralisation than that obtained from potassium fluoride. The large differences found are probably due to changes in the physico-chemical properties of the organic matter caused by treatment with alkali, as suggested by Bremner & Lees (1949). It is likely that metallic cations are more easily removed from the organic complexes, with less effect on their physico-chemical properties, by potassium fluoride reagent (which is neutral in reaction) and thus render the fulvic acid fraction more labile for mineralisation by the soil microbes.

The fractionation of the organic matter in poor and in rich cultivated tea soils was next carried out. For this purpose, tea yield figures from the various fields at St Coombs estate for a consecutive period of five years (1950 to 1955) were obtained by courtesy of the Superintendent, Mr E. S. Rose. It was found that field No. 10 gave an average yield of 1161 lb. made tea per acre per annum, the highest for this estate at that time, while field No. 2 gave 746 lb. made tea per acre per annum, the lowest figure. It was expected that the organic matter fractions in the soil from these two fields would show large differences. The results are shown in Table 5.

TABLE 5.—*Organic matter fractions of soil from high and low yielding fields at St Coombs estate*

Analysis for:	High-yielding field		Low-yielding field	
	Profile		Profile	
	0—2″	2—6″	0—2″	2—6″
Total organic nitrogen (% of soil) ...	0.363	0.315	0.305	0.254
Organic nitrogen extracted by potassium fluoride reagent (% of soil) ...	0.102	0.085	0.080	0.061
Dialysable fraction of extracted organic nitrogen (% of soil)	0.016	0.010	0.006	0.005
Organic nitrogen in humic acid fraction (% of soil)	0.043	0.035	0.026	0.015
Organic nitrogen in fulvic acid fraction (% of soil)	0.041	0.038	0.037	0.035
Percentage absorption of light of potassium fluoride extract (5 mm. cell) ...	88	84	53	27

The total organic nitrogen as well as the various nitrogenous fractions, other than the fulvic acid fraction, appear to be higher in the high-yielding field than in the low-yielding area. The large differences in the percentage absorption of light by the organic matter extract indicate the presence of a large amount of dark-coloured organic complexes in the high-yielding field. The low-yielding field (No. 2) is adjacent to field No. 1 and more or less similarly situated. It has been shown earlier (Tolhurst 1956a; Elias 1960) that the difference in behaviour to replanting between Field No. 10 and Field No. 1 is probably due to the following: (1) Field No. 10 was brought into cultivation from a rich patna area, whilst field No. 1 was formerly a jungle area; (2) Field No. 10 was planted in 1931 whilst Field No. 1 has been under cultivation since the 1880's; (3) there appears to be a slight difference in the annual rainfall in the two areas; (4) Field No. 1 has a steeper terrain than Field No. 10; and (5) the direction of the slope in the two areas is different. Similar differences exist between Fields Nos. 10 and 2 (which is similar to No. 1) and have probably been responsible for the differences in the organic matter status of the two fields.

Summary

1. Results of preliminary investigations on the fractionation of the soil organic matter in up-country tea soils (St Coombs estate) and the susceptibility to mineralisation of these fractions when incorporated into the tea soil are reported.

2. Potassium fluoride (0.5M) appears to be a better reagent for the extraction of organic matter in up-country tea soils than other neutral and alkaline reagents tried. The different reagents give about the same degree of extraction, but potassium fluoride, being neutral, is likely to cause the minimum changes in the physico-chemical properties of the organic matter.

3. The degree of mineralisation of the fulvic acid fraction of the organic matter extracted by potassium fluoride reagent (and incorporated into the soil), was found to be more than twice as much as the same fraction obtained from potassium hydroxide.

4. A comparative study of the organic matter fractions from the high-yielding and low-yielding fields at St Coombs showed that the high-yielding field was superior to the low-yielding field in its total organic nitrogen content as well as in available nitrogen.

PART II. MINERALISATION OF SOIL ORGANIC NITROGEN UNDER CONTROLLED LABORATORY CONDITIONS

The soil organic matter consists of humified and unhumified material from dead plants and animals, in different stages of decomposition, which is caused predominantly by soil micro-organisms including fungi. The mineralisation of organic nitrogen probably takes place through the following stages (Russell, 1950):

Organic nitrogen —> ammonia —> nitrites —> nitrates

These changes occurring in the field may be studied in the laboratory by incubating the soils under standard conditions. The rate of mineralisation found under these conditions is probably not exactly the same as the rate of similar change occurring under cultivated field conditions; however, the amount of decomposable organic nitrogen and the nature of the mineralised product can be assessed. The results of various experiments carried out in this connection on Ceylon tea soils are briefly described in this section. The determination of the ammonia and the nitrate was carried out according to a modified method (Ramaswamy, in press).

1. Fraction susceptible to mineralisation of organic nitrogen in tea soils from different elevations

It has been found that the soil micro-organisms become active only in the presence of sufficient water. For example, dry soils may be preserved for very long periods without any change in their mineral nitrogen content; but by subjecting the soils to a process of alternating moist and dry conditions, it appears to be possible alternately to activate and inactivate the life processes of these soil microbes. By this process, the susceptible fraction of the organic nitrogen is mineralised gradually. The following experiment was conducted to determine the number of such alternate wetting and drying processes required to give the maximum possible degree of mineralisation of organic nitrogen.

Tea soils from St Coombs and four other estates at different elevations were air-dried and spread to about a quarter-inch thickness on porcelain plates. The soils were wetted with a fine jet of distilled water to just below the saturation point (pre-determined) and allowed to air-dry in the laboratory (temperature variation 20–25°C). Depending upon the weather conditions, the soils took between 2 and 10 days to dry. The soils were wetted and dried again; the process of wetting and drying was continued several times. The mineralised nitrogen was determined at intervals. It was found that the organic nitrogen mineralised easily to ammonia, but subsequent conversion to nitrites and nitrates was negligible during the whole period. The rates of mineralisation of the organic nitrogen in various soils are shown in Fig. 2.

It may be seen from Fig. 2, that there was a rapid mineralisation of organic nitrogen up to the 36th wetting and drying treatment, after which the increase was small. The percentage mineralisation at this stage may, therefore, be taken to represent approximately the susceptible fraction.

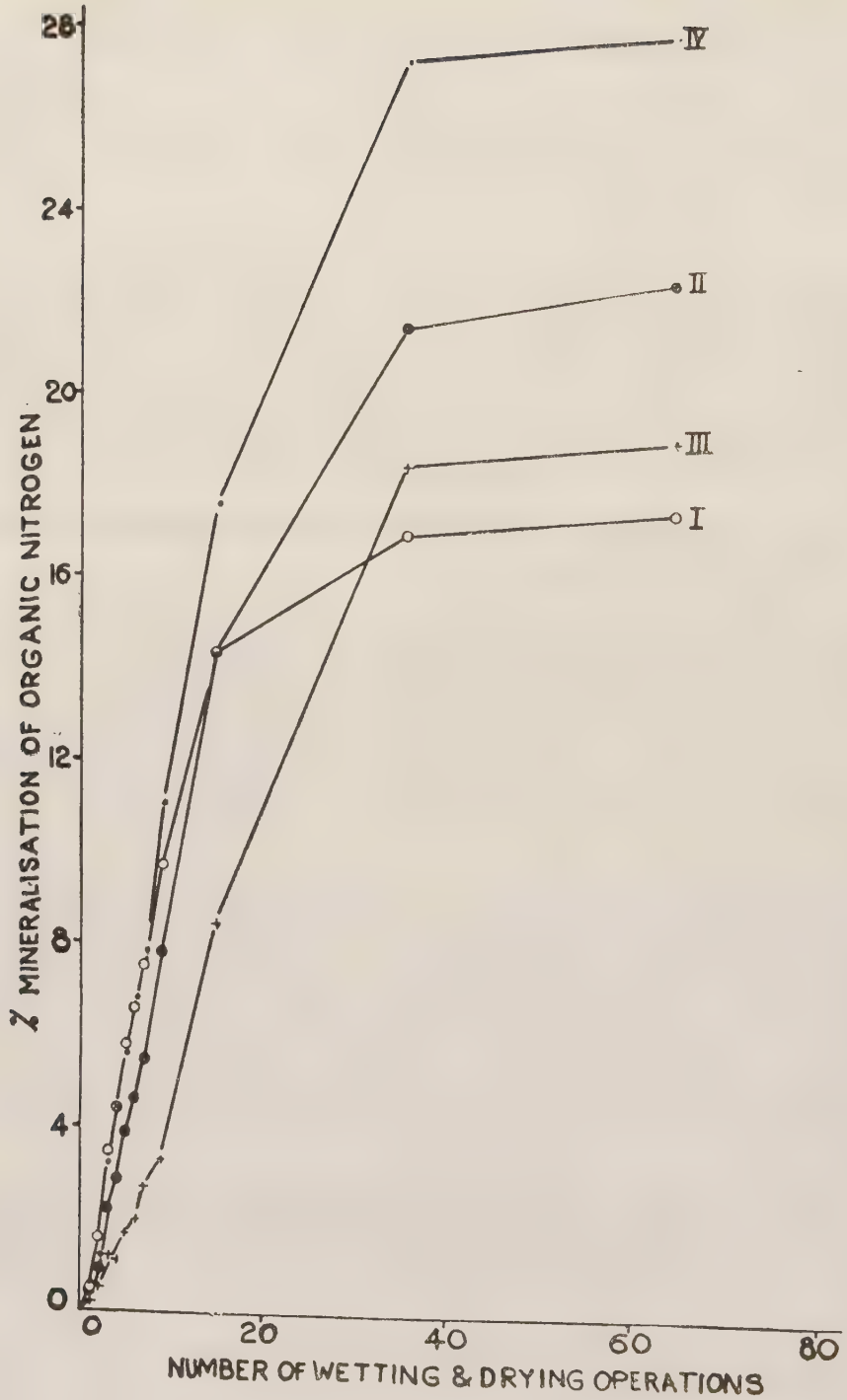


Fig. 2—Susceptibility to mineralisation of organic nitrogen from tea soils at different elevations (by alternate wetting and drying method).

I. St Coombs, 0-2″ soil (elevation 4500′ AMSL); II. St Coombs, 2-6″ soil; III. Endane, 0-6″ soil (elevation 1300′ AMSL); IV. Sapumalkande, 0-6″ soil (elevation 600′ AMSL).

It may also be seen from Fig. 2, that the organic nitrogen in the 2–6″ layer of the soil (St Coombs) was found to contain a higher percentage susceptible to mineralisation than that in the top 2″ of the soil.

The changes in the pH of the soils during the period of test were also determined. All the soils showed a steady increase in pH and this was found to vary between 30 and 50 times the initial hydrogen ion concentration.

A sample of the soil from one other district (Dartry, elevation 2,400′ AMSL, 0–6″ layer) was also treated along with the above set, but this soil was found to contain initially a large amount of exchangeable ammonia (967 ppm as nitrogen on dry soil). This high figure could not have been due to manuring since the field from which the soil was sampled was manured two months prior to sampling and there had been a rainfall of about 19 inches during this interval. (It was found on No. 8 field, St Coombs that the amount of exchangeable ammonia, after manuring with TRI-500 mixture, dropped to normal levels of 3 to 8 ppm nitrogen within 4 to 7 weeks during which there had been a rainfall of only 1.44 to 9.35 inches). The mineral nitrogen contents of this Dartry soil dropped steadily (to 736 ppm nitrogen on dry soil) during the period of test. This soil also showed an increase in pH, but to a lesser extent (only five-fold) than the other soils studied. Because of the peculiarity of the soil, and since apparently no organic matter appeared to have been mineralised, the results for this soil are not shown in Fig. 2.

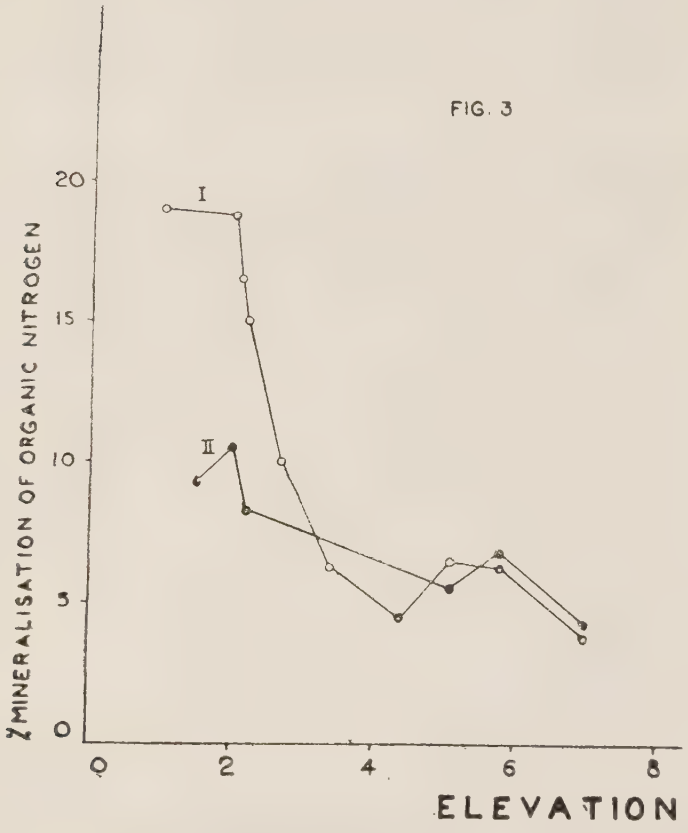
A number of tea and jungle soils (0–6″ layer) from districts at different elevations and with different climatic conditions were next examined by the wetting and drying method. In this experiment also, no appreciable amounts of nitrites and nitrates were formed; ammonia was found to occur predominantly. The results are represented in Figures 3 & 5 while the total organic nitrogen content are shown for purposes of comparison in Figures 4 & 6.

The results indicated that the susceptible fraction of the organic nitrogen was generally higher in the tea soils than the jungle soils; it was also found to be higher in the mid-country soils than in the up-country soils in both the S.W. and the N.E. monsoon zones. Sufficient information about the low-country tea soils could not be obtained as only one sample from districts below 1,000 ft elevation was available. From these results, it is possible to speculate about the nature of changes that occur in the organic nitrogen in the mid-country districts. It would appear that in this region, particularly under the prevailing climatic conditions (frequently alternating wet and dry conditions) the rate of mineralisation of the organic nitrogen may be expected to be equal to if not higher than any building-up processes.

The susceptible fraction of the organic nitrogen in soils from different elevations (both in S.W. and N.E. monsoon zones) was found to decrease as the elevation increased while the total organic nitrogen increased as the elevation increased. The statistical significance of these results is shown in Table 6.

TABLE 6.—*Correlation coefficients on the relationship between elevation and the susceptible and total organic nitrogen in soils*

	Susceptible fraction of organic nitrogen, and elevation		Total organic nitrogen, and elevation	
	Tea Soils	Jungle Soils	Tea Soils	Jungle Soils
Correlation coefficient	—0.702	—0.839	+0.796	+0.783
t (calculated)	3.425	4.086	4.570	3.334
t (tabulated) @ 1% probability ...	3.055	3.499	3.055	—
t (tabulated) @ 2% probability ...	—	—	—	2.998



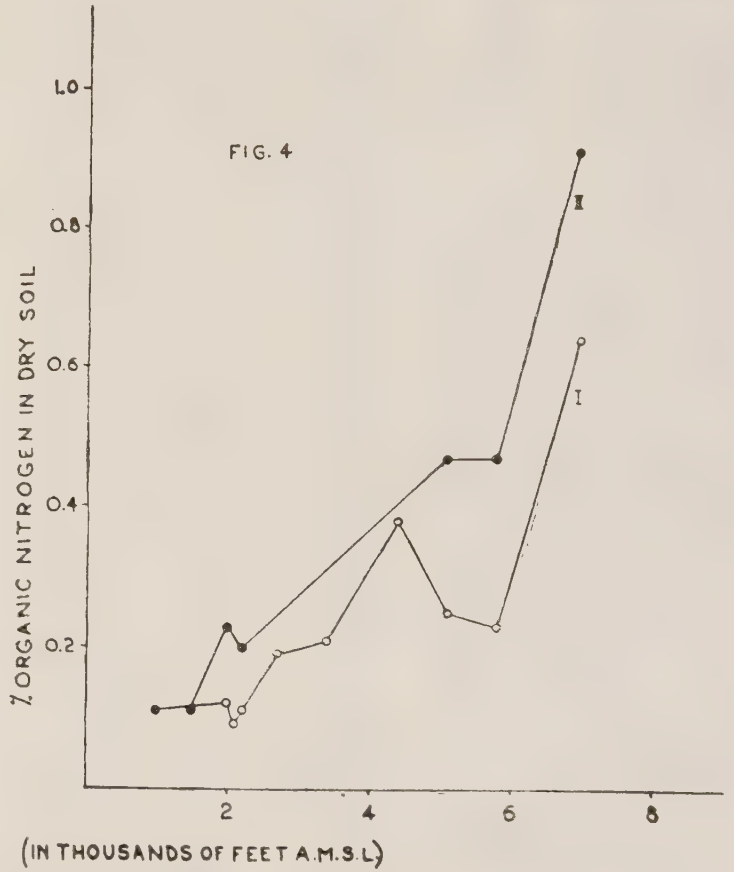
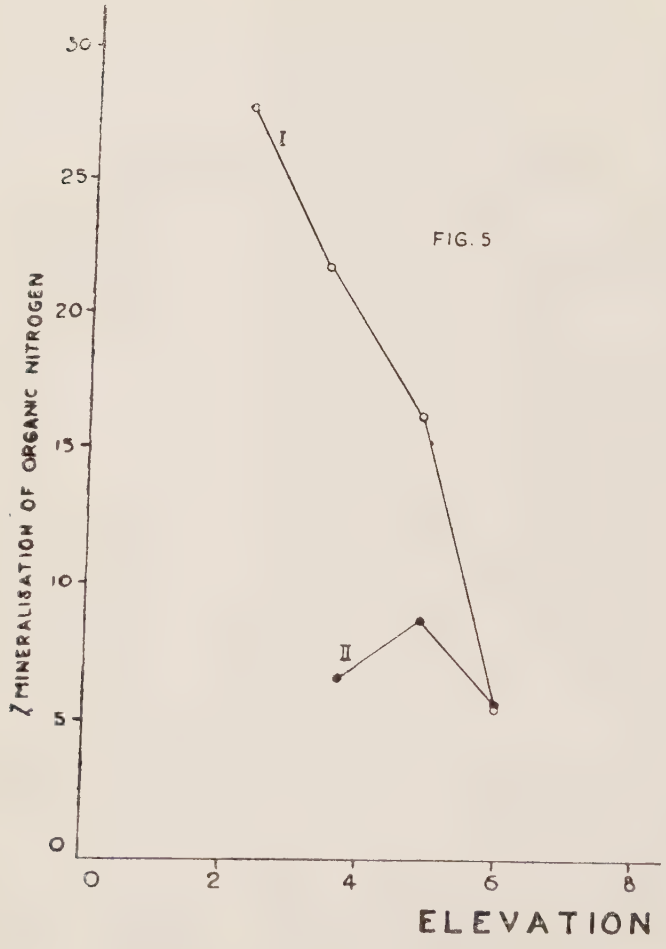


Fig. 3—Percentage mineralisation of organic nitrogen in the tea (I) soils and the jungle (II) soils from districts at different elevations in the S.W. Monsoon zone.

Fig. 4—Organic nitrogen content of the tea (I) soils and the jungle (II) soils from districts at different elevations in the S.W Monsoon zone.



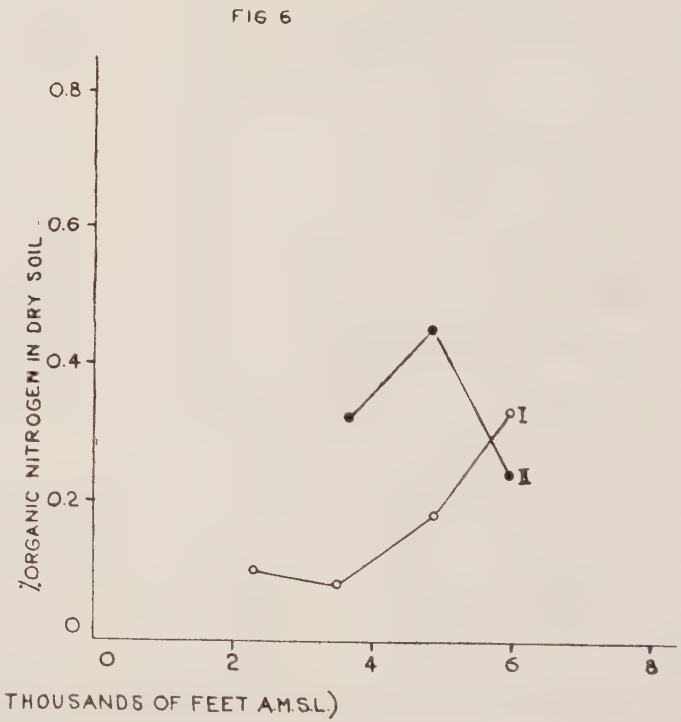


Fig. 5—Percentage mineralisation of organic nitrogen in the tea (I) soils and the jungle (II) soils from districts at different elevations in the N.E. Monsoon zone.

Fig. 6—Organic nitrogen content of the tea (I) soils and the jungle (II) soils from districts at different elevations in the N.E. Monsoon zone.

TABLE 7.—*Mineralisable organic nitrogen in different soils, expressed as tons of ammonium sulphate per acre*

S.W. MONSOON ZONE						N.E. MONSOON ZONE					
TEA SOILS			JUNGLE SOILS			TEA SOILS			JUNGLE SOILS		
Estate No.	Elevation ft	Tons of $(NH_4)_2SO_4$ per acre	Estate No.	Elevation ft	Tons of $(NH_4)_2SO_4$ per acre	Estate No.	Elevation ft	Tons of $(NH_4)_2SO_4$ per acre	Estate No.	Elevation ft	Tons of $(NH_4)_2SO_4$ per acre
1	100	12.8	1	1,500	5.8	1	2,300	12.0	1	3,700	11.2
2	1,000	10.4	2	2,000	13.6	2	3,500	8.4	2	4,900	17.5
3	2,000	9.9	3	2,200	8.3	3	4,900	8.0	3	6,000	14.1
4	2,100	7.3	4	5,100	17.5	4	6,000	11.2			
5	2,200	7.6	5	5,800	17.3						
6	2,700	9.2	6	7,000	28.0						
7	3,400	7.3									
8	4,400	9.6									
9	5,100	8.9									
10	5,800	7.6									
11	7,000	16.8									

Laboratory incubation studies showed that most of the mineralised ammonia in these experiments was available (under conditions suitable for nitrification) for conversion to nitrites and nitrates by the nitrifying organisms.

As a matter of general theoretical interest, the amount of mineralised nitrogen in all the soils investigated was expressed as tons of ammonium sulphate per acre (assuming two million pounds of soil per acre, 6″ deep), and the data are given in Table 7.

These figures give a rather surprising picture of the available organic nitrogen in Ceylon tea soils. Moreover, the data are in no way exhaustive; only the top six inches have been considered and the mineralisable fraction of the total organic nitrogen may in fact be much higher. The organic matter returned to the soil in the form of prunings, and dead leaves of tea and shade trees, which is known to be very substantial (Visser, 1960), has not been considered here. Nevertheless, it is of course known from practical experience, that regular additions of inorganic manures are necessary to maintain high yields. The minimum rate advised for this is 8 lb. of nitrogen to 100 lb. made tea and a 10 lb. rate is commonly used ; thus a yield of 1,000 lb. per acre requires approximately 0.21 tons of ammonium sulphate per annum. Yet, looking at the figures of Table 7, the available nitrogen is the 'equivalent' of this supply for 35–80 years of cultivation. The explanation of this must be that in natural conditions, mineralisation does not occur fast enough or to such an extent as was produced in the laboratory in these experiments.

Further it is quite essential to *maintain* a high level of organic matter in soils, to sustain the soil microbes and to maintain the soil structure and moisture-retaining capacity. Liberal applications of nitrogenous fertilisers must be made, particularly when estates are likely to produce higher yields following replanting with high-yielding clonal material. Special attention should be paid in the mid-country districts to increasing the total organic matter content of the soil.

2. Incubation studies

(a) Mineralisation of organic nitrogen in incubated soil

St Coombs cultivated tea soil was taken from field No. 10 at different depths and air-dried. The soil was crushed, and incubated in a continuously humid atmosphere at 30°C. The mineralised nitrogen was determined at intervals. The results are shown in Table 8.

TABLE 8.—*Rate of mineralisation of soil organic nitrogen*
(Results expressed as % conversion of organic nitrogen to ammonia)

Soil profile	Days of incubation				
	7	14	21	28	35
0— 6″	— 0.4	0.1	1.2	1.0	1.5
6—12″	0.6	0.2	1.6	1.3	1.9
12—24″	1.7	0.8	2.0	0.8	1.9
24—36″	1.5	2.1	0.4	1.3	0.4
36—60″	6.9	10.9	5.6	— 2.4	3.4
60—84″	13.4	11.0	10.3	12.2	8.4

The degree of mineralisation of organic nitrogen to ammonia was found to be higher in samples from below 36″ than in those from above this level; evidently the organic nitrogen in sub-soils is more susceptible to mineralisation than that present

in top soils. The results for nitrification have not been shown in Table 8, since this was found to occur very little, probably because the soils were incubated at very low moisture levels (4–6%).

(b) Effect of added potassium nitrate on the formation of ammonia and the activity of the soil fungi under different conditions.

In order to study this, use was made of lysimeter tubs, previously described by Lamb (1954). These are essentially steel tubs, in which tea bushes are grown in soil, with piped drainage so that the soil drainage water can be collected, measured and analyzed.

A set of lysimeter experiments was initiated during August 1953, mainly for the purpose of determining the rate of percolation of rain water through the same tea soil (St Coombs No. 10 field) and also the loss of inorganic nutrients in the drainage water. Results obtained from September 1953 to August 1954, particularly after treatment with potassium nitrate are of interest in relation to the formation of ammonia, the loss of added nitrate and the growth of soil fungi. Addition of potassium nitrate appeared to increase the ammonia content of the drainage water, particularly during a spell of rainy weather. The results are summarised in Table 9.

TABLE 9.—*Increase in the ammonia content of drainage water during wet weather in lysimeters treated with potassium nitrate*

Weather conditions and date	Potassium nitrate added to each lysimeter (g)	Ammonia as nitrogen in the drainage water (average of two sets)			
		Lysimeter without tea bush		Lysimeter with tea bush	
		ppm	Total (mgs)	ppm	Total (mgs)
1. Fairly dry season, 16th September, 1953 to 1st December, 1953 ...	Nil	0.42	24	0.50	25
2. Fairly dry season, 2nd March, 1954 to 25th May, 1954	20.93	0.41	19	0.15	8
3. Wet season, 26th May, 1954 to 18th August, 1954	5.27	9.32	1158	1.70	262

It may be seen from the results in Table 9, that the lysimeter (with or without the tea bush), after a treatment with potassium nitrate, showed a very high loss of ammonia in the drainage water during the wet season as compared with losses during the dry seasons. It is therefore reasonable to assume that, during the wet weather conditions, addition of potassium nitrate had either greatly stimulated the mineralisation of soil organic nitrogen to ammonia, or the nitrates were reduced to nitrites and ammonia.

Laboratory incubation studies on St Coombs cultivated soil confirmed the findings of the lysimeter studies. Loss of nitrate nitrogen was found in top soil (0–24″) at high moisture levels and particularly under anaerobic conditions (Table 10). Addition of potassium nitrate stimulated the formation of ammonia, probably by mineralisation of the soil organic nitrogen (Table 12); but the loss of nitrate nitrogen could not be explained by this (Table 11).

The soils, however, particularly those showing heavy losses of nitrates, were found to contain an abundance of soil fungi (particularly of the *Penicillium* group).

The experimental results are shown in Table 10–12.

TABLE 10.—*Loss of added nitrate nitrogen under different experimental conditions*

(Results expressed as % loss or gain of nitrate nitrogen compared to the initial content)

(*a*) St Coombs cultivated soil, 0–6″ layer from field No. 10, incubated when one-third saturated with water at 30°C, under anaerobic conditions (continuous flow of humid carbon-dioxide gas over the soil).

Days of incubation ...	12	18	27	34	42
% Loss or gain ...	—20	—14	—13	—12	—15

(*b*) St Coombs cultivated soil, profile from field No. 10, incubated at slightly below the saturation point of water at 30°C, under anaerobic conditions (continuous flow of humid carbon dioxide gas over the soil).

Soil profile	Days of incubation				
	3	7	11	13	18
0— 6″	—38	—90	—87	—92	—100
6—12″	—51	—24	—21	—87	—100
12—24″	+ 1	—10	— 5	— 2	— 14
24—36″	—19	+11	+22	+11	+ 6
36—60″	+10	+ 2	+ 2	— 1	— 1
60—84″	+ 9	+ 2	+16	+17	+ 12

(*c*) St Coombs cultivated soil, 0–6″ layer from field No. 10, incubated at slightly below saturation point of water at 30°C, under aerobic conditions (continuous flow of humid air over the soil).

Days of incubation ...	10	20	27
% Loss or gain ...	—31	— 9	— 6

TABLE 11.—*Loss of mineral nitrogen (ammonia + nitrate) under different experimental conditions.*

(Nitrite was found to be in traces only)

St Coombs cultivated soil, 0–6″ layer from field No. 10, incubated at 30°C under aerobic conditions. (Mineral nitrogen added=200 ppm of the soil).

(Results expressed as % increase over the initial content)

Experimental details	Days of incubation			
	7	14	42	56
Moisture level at 25%				
(*a*) Soil only (Control)	75	85	92	92
(*b*) Soil + Potassium nitrate ...	0	— 3	3	—16
Moisture level at 35%				
(*a*) Soil only (Control)	62	100	100	131
(*b*) Soil + Potassium nitrate ...	6	—11	1	—25

TABLE 12.—*Formation of ammonia in the presence of added potassium nitrate* (200 *ppm of the soil*).

St Coombs cultivated soil, 0–6″ layer from field No. 10, incubated at 30°C, under aerobic conditions.

(Results expressed as % increase over the initial content)

Experimental details	Days of incubation			
	7	14	42	56
Moisture level at 25%				
(*a*) Soil only (Control)	25	8	0	—17
(*b*) Soil + Potassium nitrate ...	195	242	431	550
Moisture level at 35%				
(*a*) Soil only (Control)	0	8	—17	8
(*b*) Soil + Potassium nitrate ...	180	260	407	520

In the set of lysimeter experiments described earlier in this paper, it was also found that nearly 50 per cent of the added nitrate (in the lysimeters without the tea bushes) could not be accounted for, either in the drainage water or in the soil itself. The soil was found to contain abundant fungi, especially those of the *Penicillium* group. It is probable, therefore, that the 'missing' nitrate was utilised by the soil fungi and possibly by other micro-organisms. In tea areas with heavy and continuous rainfall, nitrate losses due to leaching are probably not as high as one might expect; for under such conditions, the nitrate is probably utilised by the vigorously growing soil fungi. After death, the soil fungi are probably decomposed by the soil bacteria, which then gradually release the mineralised form of nitrogen. If this is

correct—and further studies are needed to confirm it—it means that there is a natural safeguard against excessive loss of soil nitrate due to leaching, in areas with prolonged heavy rainfall.

Summary

1. Experiments on some Ceylon tea and jungle soils to evaluate the fraction of the total organic nitrogen that is susceptible to mineralisation are reported. Samples of soils from districts at various elevations in the S.W. and N.E. monsoon zones were examined.

2. Repeated wetting and drying of the soils was used in the laboratory to cause mineralisation of the susceptible nitrogen fraction. In all the soils examined, little mineralisation to ammonia occurred after about 36 wet and dry treatments; the percentage mineralisation at this stage was taken to represent the susceptible fraction.

3. The total organic nitrogen, and the susceptible fraction, differed considerably in the various samples, and significant correlations were found to exist between the elevation (from which the sample was taken) and total organic nitrogen (positive correlation), and between elevation and the susceptible fraction (negative correlation). Thus, with increasing elevation, total organic nitrogen contents were generally higher, but the fractions of these which were susceptible to mineralisation were less. This was true for soils from both the S.W. and the N.E. monsoon zones. Only one sample from below 1,000 feet was examined.

4. Nevertheless, mineralisable organic nitrogen appeared to be fairly abundant in all the tea soils studied, and the amount available (as distinct from the fraction) had no definite correlation with elevation.

5. Lysimeter studies showed an increase in the ammonia content of the drainage water under wet weather conditions when potassium nitrate was added. They also showed that part of the added nitrate nitrogen could not be accounted for either by its presence in the soil or by removal in the drainage water. The soil contained an abundance of soil fungi, particularly of the *Penicillium* group; the nitrate was probably utilised by the rapidly-growing fungi.

6. Laboratory incubation studies confirmed the results of the lysimeter experiments.

Acknowledgment

I am grateful to Mr J. Lamb and Mr J. A. H. Tolhurst for their kind interest in these investigations. The soil samples from estates other than St Coombs were kindly provided by Mr J. A. H. Tolhurst of the Agricultural Chemistry Division while the examination of the treated soils for fungi was kindly carried out by Mr B. N. Webster of the Pathology Division.

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NITROGEN DEFICIENCY IN CLONAL PLANTS

D. Mulder and T. Visser

Our experience with clonal material has indicated that clonal plants often show deficiency symptoms, *e.g.* of magnesium (Mulder & De Silva, 1959) and nitrogen, much more clearly than does seedling tea.

Apart from the fact that a symptom is always more noticeable on an area with uniform plants than on an area with genetically different seedling plants, the explanation of this phenomenon is probably two-fold:

(1) a clonal plant, having been specially selected for vigorous growth, generally grows more quickly and produces more flush than most plants grown from seed. Accordingly, its food requirements are higher than those of most seedling plants, which grow more slowly;

(2) although clonal plants will eventually have an extensive root system, which will penetrate to the same soil levels as the tap roots of seedling plants do, it seems possible that clonal plants may have initially more superficial roots. This will make them more sensitive to drought at first, but also more responsive to fertiliser application.

Acute nitrogen deficiency symptoms in the flush were not commonly observed before the development of vigorously growing clones, such as TRI 2024. Plants of this clone (and of certain others, and even some seedlings) often develop a typical pinkish-yellow flush, which was at first thought to be a genetic character, but was later proved to be a manurial deficiency (Visser, Kehl & Tillekeratne, 1959). This characteristic is only genetical in so far that clone 2024 may show it more noticeably than other clones.

Experimental

It was suspected that the element lacking was nitrogen so that in order to confirm this conclusively a trial was done in which the nitrogen was applied in the form of urea. In this trial four-year old bushes of clone 2024 which showed pink-leaf symptoms were sprayed once, twice, three and four times respectively with 6% urea at weekly intervals and at a rate of about 75 gallon solution per acre; each treatment was represented by 5 bushes; bushes sprayed with water served as a control.

All pinkish leaves were counted at the start of the trial and thereafter weekly; distinction was made between undamaged leaves and damaged ones (*e.g.* by blister blight) taking into account the possibility that the pink colour of damaged leaves may be rather a wound reaction than a deficiency symptom.

TABLE 1.—*The number of pink leaves per 5 bushes (number of damaged pink leaves between brackets) after spraying with 6% urea: (a) 0, (b) 1, (c) 2, (d) 3 and (e) 4 times respectively, at weekly intervals.*

Column: 1	2	3	4	5	6
Times Sprayed	Date of Assessment				
	26/8/60	2/9/60	9/9/60	16/9/60	23/9/60
(a) 0x	103 (32)	135 (46)	123 (30)	122 (30)	126 (28)
(b) 1x	152 (68)	109 (43)	119 (28)	100 (4)	124 (17)
(c) 2x	91 (33)	80 (34)	30 (10)	23 (0)	10 (4)
(d) 3x	101 (35)	84 (41)	27 (16)	8 (0)	0
(e) 4x	101 (32)	87 (46)	38 (17)	18 (0)	0

Columns 2, 3, 4 and 5 give the dates of the 1st (start of trial), 2nd, 3rd and 4th sprays respectively.

It will be seen from Table 1 that the spraying with urea rapidly cured the nitrogen deficiency symptoms; two weeks after the trial started, the bushes which were sprayed twice by that time (column 4: *c, d, e*) had markedly less pink leaves, whether or not damaged, as compared with the control (*a*). Two weeks later (column 6), the symptoms had completely disappeared on bushes sprayed three and four times and nearly so on bushes sprayed twice. The bushes were completely green at that time, producing healthy shoots. Judging by the undiminished number of pink leaves, spraying once (*b*) was not successful, though it was observed that the leaves were less pink or yellowish than those on the unsprayed bushes.

The spraying caused some scorch, which after 1, 2, 3 and 4 spraying rounds amounted to 0, 3, 6 and 17% respectively of the shoots which were present 4 weeks after the experiment started. The damage was, however, not severe and scarcely noticeable two weeks later.

A similar trial was carried out with a 3% urea spray, applied once, and twice with an interval of a week. Three weeks after the single spray and two weeks after the double spraying, the number of pink leaves amounted to 1/3rd and 1/5th respectively of the number on the control plot, thus again showing a rapid disappearance of the deficiency symptoms; no scorch occurred.

Conclusions

Unless planters are aware of the tendency of certain clones to suffer more acutely than seedling tea from mineral deficiencies, and are able to recognise these deficiencies and to take remedial action, trouble may result. For this reason, the symptoms of nitrogen deficiency in TRI 2024 are illustrated in the colour plate (No. 2)* accompanying this note. Naturally the symptoms are not so evident in all instances and with all clones. In certain cases the young leaves may be very light yellow or have only a pinkish hue. The symptoms of this deficiency develop particularly when the plants are first put into baskets and again when they are planted out in the field.

There are several possible treatments for acute nitrogen deficiency symptoms:

(1) better distribution of the present quantity of nitrogen over the year by more frequent manuring with smaller quantities of fertiliser;

(2) an extra dose of ammonium sulphate. It should be stressed that this is only advised for confirmed acute cases of nitrogen deficiency, and this does not mean a change in the manuring policy of the Tea Research Institute;

*Colour Plate No. 1, of magnesium deficiency, was published in the Tea Quarterly, December 1959.

Fig.1. - Nitrogen deficiency - Clone TRI 2024

Fig.2. - Healthy shoot - Clone TRI 2024

(3) foliar application of nitrogen by spraying of urea. The described experiments, confirming those done at the Tocklai Experimental Station (Dutta, 1959), have shown that this is indeed a possibility. It would not be practical commercially to spray such large quantities of solution (75 gallons per acre) as we did, but it is likely that several sprays of 6% urea at the rate of 20 gallons per acre would also have the desired effect. If urea can be mixed with the fungicide used against blister blight, then no extra cost, apart from that for the urea itself, will be incurred. There is, however, the possible danger of a corrosive action of the mixture to spraying machines. This point is under investigation.

Acknowledgments

We gratefully acknowledge the assistance of Messrs Rajendram and Hassim in carrying out the urea spray trial.

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BIOLOGY AND CONTROL OF THE FRINGED NETTLE GRUB

(*Macroplectra* (*Natada*) *nararia* Mo.)

J. E. Cranham & E. F. W. Fernando

Nettle grubs are well known in Ceylon, particularly to Uva planters, as a pest of tea that has been troublesome for over sixty years. They are the larvae of moths of the family Cochlidiidae (*Limacodiidae*) in which the species of economic importance are mainly tropical in distribution, being pests on tea, coconuts, plantains, coffee, oil-palms, and other plants. Both the structure of the larvae and the form of the cocoons in which they pupate are unusual amongst Lepidoptera, although despite their economic importance the family has not been as much studied as many others, including their equally unusual relatives, the Psychidae or Bagworm moths. Not all cochlidiid larvae are called nettle grubs; the name is due to the presence of stinging (urticating) spines on the body; some species are called slug caterpillars or gelatine grubs. All have thick short fleshy bodies, a small retractile head and minute thoracic legs; the segmentation is indistinct, and there are no abdominal feet, although in some species there are secondary sucker discs on the first eight abdominal segments. The cocoons are nearly spherical in shape, off-white to brown in colour, so that superficially they resemble a large seed; they possess a lid or operculum through which the adult moth emerges.

The species occurring on tea in Ceylon, and the history of their occurrence as pests, were reviewed in detail by Austin (1931, 1932, 1932a) and by Hutson (1923, 1932, 1932a). The commonest species causing severe damage to tea has continued to be the Fringed Nettle Grub (*Macroplectra* (*Natada*) *nararia* Moore). The Blue-striped Nettle Grub (*Parasa lepida* Cram.) is quite common in much smaller numbers, whilst *Thosea* spp. have in recent years caused local damage very occasionally (Austin, 1957). The purpose of the present article is to record the facts known about the Fringed Nettle Grub and to report recent work on the control of this pest. All further reference in this article to 'nettle grubs' implies the Fringed Nettle Grub unless otherwise stated.

Distribution and Economic Importance

Outbreaks of the Fringed Nettle Grub are commonest in the Uva Province, particularly in the Passara, Badulla and Bandarawela districts, though severe outbreaks have occurred occasionally in districts outside Uva, notably in Dolosbage and Matale. In Uva they occur mostly above 4,000 feet, and even above 6,000 feet. The incidence of outbreaks varies greatly from year to year, being affected directly or indirectly by weather conditions. The pest was reported from 35 estates in 1959 and it is clearly the most injurious caterpillar pest of Ceylon tea at the present time. No estimates have been made of the acreage affected by nettle grubs in a bad year, but this would appear to be several hundred acres and occasionally a few thousand acres. Whilst this is a small percentage of Ceylon tea, it is a serious problem on those estates which have several fields affected. A severe outbreak not uncommonly results in the complete defoliation of whole fields with the loss of crop for many weeks. The pest is most common in the dry weather of the N.E. monsoon zone, and outbreaks usually occur from July to September, although severe attacks have been known to continue through wet weather later in the year. In the S.W. monsoon zone, attacks are most likely to occur from March to May.

Plate 1. Larvae of the Fringed Nettle Grub (*Macroplectra nararia* Moore)

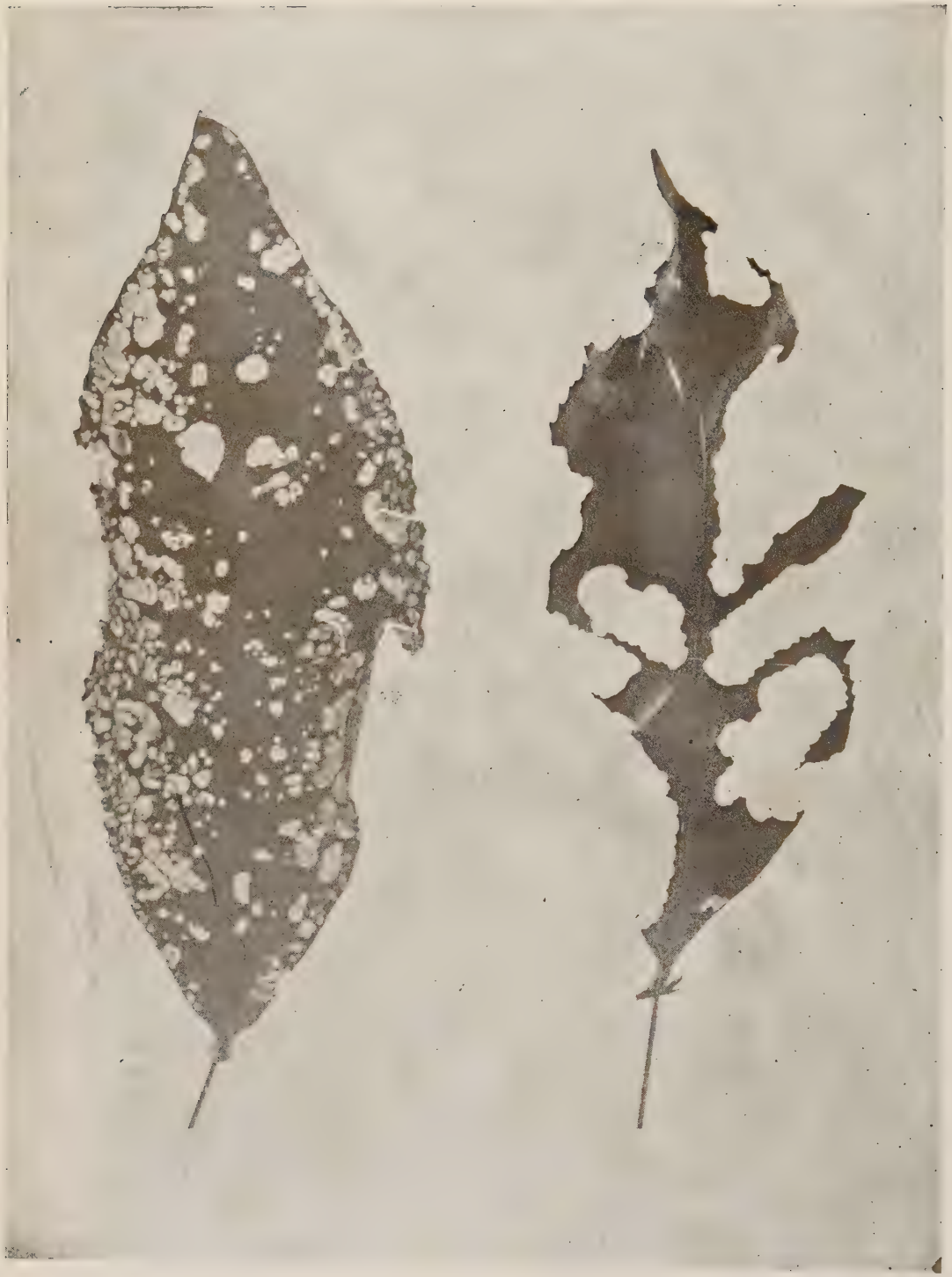

Plate 2. Damage to tea foliage caused by young and older larvae of the Fringed Nettle Grub.

Life-history and Description

The eggs are not easy to find since they are laid singly by the female moth on upper surfaces of mature leaves. They are oval and flattened, 1.25 mm × 1 mm in size, at first pale-yellow, or greenish when seen on a leaf, but they become opaque or pale-brown before hatching. They have a shiny appearance, which is the most distinctive feature for finding them. Many eggs may be laid on a single leaf. They hatch after about one week.

Although the eggs are laid on the upper surfaces of leaves, the newly-hatched larvae, which are 1/25th of an inch long, always migrate to, and begin feeding on, the undersurface of leaves where at first they eat away small areas leaving only the upper epidermis of the leaf intact. When about two weeks old (3rd instar) the grubs are able to eat right through the leaves resulting in a quite different appearance of damaged leaves (see Plate 2). In serious attacks every part of all the foliage may be consumed leaving the frames of the bushes completely bare.

The older larvae, 10-12 mm in length when mature, are illustrated in Plate 1. The ground colour is pale yellowish-green to apple green and the median dorsal strips is darker, predominantly purple, bordered on both sides with pale yellow. The lateral fringe of hairs which accounts for the common name of this species, consists of nine pairs of tubercles bearing tufts of pale translucent urticating hairs. There are also two pairs of anterior tubercles bearing much shorter hairs. The larval stage lasts 5-6 weeks.

The mature larvae pupate mostly on the ground beneath the bush, among dead leaves or in crevices amongst stones, and sometimes on the lower branches of the bush. They spin a cocoon which is globular, one-sixth of an inch in diameter, consisting of a hard papery shell covered with a thin webbing of dark brown or purplish-brown silk. Inside this cocoon the grub pupates and emerges about three weeks later by pushing off the circular lid or operculum prepared by the grub.

The adults are inconspicuous, very pale brown moths of which a description has been quoted by Austin (1932), from whom the following details are quoted. Austin found that female and male moths lived for 3 to 12 days in captivity, averaging six days. Moths rest up during the day and become active at dusk; egg-laying, which commenced on the day following emergence, was carried out mainly between 6-30 p.m. and midnight. Females laid about 500 eggs, most of them within three to four days of emergence. Austin observed that the moths were not active on windy nights, and a mass migration of the moths has never been observed.

The life-cycle from egg to adult takes about ten weeks according to Austin (1932) and this fits in well with the frequency of generations observed by Gadd *et al* (1946) so that there are probably five generations in a year. Peak numbers most frequently occur in July to September, but this is very variable and little is known of the cause of outbreaks.

The Fringed Nettle Grub in Ceylon is known to complete its life-cycle only on tea, coffee, and dadap (*Erythrina lithosperma*). Grubs have been found feeding on many other trees and shrubs in small numbers, but there is no evidence of them maturing on these plants.

Natural enemies

The following insect parasites have been reared from *M. nararia*:—

Fornicia ceylonica Wilkn.
Rhogas sp.
Goryphus variibalteatus Cram.
Tricholyga sorbillans Wd.
Euplectrus sp.
Neoplectrus maculatus Ferr.
Platyplectrus natadae Ferr.
Autoplectrus taprobanes Gadd.

Gadd (1946) and Gadd, Fonseka and Ranaweera (1946) made a detailed study of the Euplectrini, tiny wasp-like parasites of young nettle grubs, comprising the last four species listed above. *Neoplectrus maculatus* is unusual in that the adult females are predators, feeding on the body fluids of nettle grubs, whilst the larvae are parasites of the nettle grubs (Gadd and Fonseka, 1945). *Fornicia ceylonica* and *Rhogas* sp. were noted by Austin (1931) and have been found frequently since that time, but little is known about the normal balance between the host and these various parasites and the effect of other factors upon it.

The adults and nymphs of the Pentatomid bug *Cantheconoidea robusta* Wolff. have been noted on several occasions as predacious on nettle grubs. The Crow (*Corvus splendens*) is the only bird recorded as feeding upon nettle grubs (Austin, 1931).

Wilt Disease

The virus disease known as wilt or granulosis disease is an important factor in the natural control of nettle grub populations. The disease is transmitted from one larva to another by contact or by ingestion with the foliage eaten. A grub suffering from wilt disease soon becomes sluggish and loses appetite. The normal green coloration of the body changes to a dull yellow (a bright yellow is characteristic of insect-parasitized grubs); finally the grub becomes motionless and the body turns to a brown colour at the time of death. At this stage, the larva is entirely flaccid, emitting an offensive smell and the internal tissues have disintegrated.

Most virus diseases of insects are specific to one species or affect only a few. Thus, wilt disease of the *M. nararia* affects *Parasa lepida* only slightly and does not appear to affect *Thosea* species of nettle grubs at all. Under conditions in the field, the spread of wilt disease is increased by high host-density and generally by humid air conditions and wet weather. It does not normally become epidemic in an outbreak of nettle grubs until the grubs are nearly all mature and the major part of the damage to the tea bushes has been done. It is commonly epidemic at the onset of the N.E. monsoon in Uva, but this is not always the case, and outbreaks of the pest have been known to continue through very wet weather.

Virus diseases of insects are well known, particularly in lepidopterous larvae (butterflies and moths), and the study of this subject stemmed to a large extent from early work on 'jaundice' in the silkworm. Over sixty years ago, workers started experiments on the artificial use of these virus diseases for the control of insect pests, and in recent years, successful use has been made of some of them. Notable instances include the control of the Alfalfa caterpillar, *Colias eurytheme* Boisd. in the U.S.A. (Thompson & Steinhaus, 1950), the Wattle Bagworm, *Kotochalia junodi Heyl.* in South Africa (Ossowski, 1957), and the cabbage caterpillars *Pieris brassicae* L. and *P. rapae* L. in Hawaii (Tanada, 1955).

Thus the possibility exists of artificially spreading the disease by spraying a suspension of the virus on the bushes attacked by nettle grubs and initiating an epidemic when the larvae are quite young.

Little is known about the interactions of wilt and insect parasites as controlling factors of nettle grubs. Gadd *et al* (1946) have shown that, as would be expected, parasites cannot develop in a host suffering from wilt, and it seems likely that wilt is sometimes responsible for upsetting the balance between the nettle grub and its insect parasites. When outbreaks occur, they are sometimes brought under control by wilt within the span of a single generation, but never by insect parasites. Nevertheless, the latter may be of considerable importance in the normal balance of populations.

Recent Experiments on Control

Virus Wilt Disease

A previous experiment was reported by Austin (1958) using a spray solution of a semi-purified granulosis virus from the Fringed Nettle Grub prepared by Dr K. M. Smith of the A.R.C. Virus Research Unit, Molteno Institute, Cambridge, U.K. An epidemic of the wilt disease was successfully spread amongst a population of nettle grubs at Passara. In view of these results we carried out a further trial on an estate in Uva in 1959; in this instance the suspension of the virus was prepared simply by macerating diseased larvae in blood albumen solution (Tanada, 1955). The details of this trial are as follows:—

Groups of two, three and five dead Nettle Grubs which had died from wilt disease were separately macerated, each group in 50 c.c. of 0.2% blood albumen solution. Each 50 c.c. suspension was then diluted before spraying with 0.75 gallons of water.

Six small plots of ten bushes each, which were naturally infested with Nettle Grub, were marked out. Three of these were sprayed with the three different 'concentrations' of virus. The three other plots were sprayed as controls with water only. The Nettle Grub larvae at the time of spraying were small, being second and third instars. Counts were made at intervals after spraying of the number of (1) healthy, (2) wilted and (3) obviously parasitised larvae on all plots.

There were no obvious differences in effect between the concentrations of virus used, and in Table 1 the numbers for the three sprayed plots and for the three unsprayed plots are grouped together.

TABLE 1.—*Results of Experiment* 1 *on control with wilt disease*

Days after spraying	Date	No. of living larvae per 150 leaves (30 bushes)					
		TREATED PLOTS			UNTREATED PLOTS		
		Healthy	Wilted	Parasitised	Healthy	Wilted	Parasitised
0	10. 8.59	265	0	0	214	0	0
9	19. 8.59	121	2	0	174	0	0
14	24. 8.59	162	30	0	346	0	3
22	1. 9.59	75	24	1	349	6	1
40	19. 9.59	2	19	0	30	12	2
57	6.10.59	12	4	1	8	4	4
67	16.10.59	227	0	1	292	0	3
81	30.10.59	447	17	2	326	8	1
88	6.11.59	222	23	2	225	14	0
95	13.11.59	83	16	1	98	7	0

The results suggest that a good degree of control took place within three weeks of the spraying (note numbers for 14 and 22 days after spraying), which was by the time the Nettle Grub larvae matured. It was further observed, in visual comparison of the sprayed and unsprayed plots that a fair part of the foliage damage caused by the Nettle Grub was prevented by spraying. However, the speed of

action, which was quite similar to the results previously reported by Austin (1958), left much to be desired and was very much slower than that obtained by effective insecticides.

In order to see whether the virus persisted on the foliage for more than the span of a single generation, counts were continued after the first generation of larvae had matured and pupated. On these very small plots, there was a heavy reinfestation of the treated plots (on which the population had been reduced) from outside. Thus, the counts shown in Table 1, for 67-95 days after spraying, record the numbers of the second generation. The numbers for the treated and untreated plots were very similar and there was no evidence that the virus persisted on the foliage for more than the span of the first generation, about six weeks.

Chemical Control

The use of the detergent "Teepol" (Shell Co. of Ceylon) at a concentration of 1%, as an alternative to common soap solution, was tested and recommended by Austin (1957) and several estates have made use of this chemical. By 1959, reports of the use of Teepol on a fairly large scale were far from encouraging, and it was decided to retest Teepol and compare it with two possible insecticides of low mammalian toxicity—DDT and malathion. Austin (1958) had also reported very good results with endrin, but this insecticide is toxicologically far too dangerous to be used for spraying tea.

The detailed results of a replicated small plot experiment (2) carried out in 1959 are given in Table 2. Each of five treatments was applied to four plots of 25 bushes in a randomised block design. The sprays were applied by pressure-retaining knapsack sprayers at a rate equivalent to 60 gallons of spray per acre; two applications were made at an interval of five days. The concentrations given in Table 2 are percentages of the actual insecticide in the diluted spray. The following proprietary formulations were used: a malathion 50% emulsifiable concentrate, a DDT 50% wettable powder, and a DDT 25% emulsion. 'Teepol' is supplied as the unformulated detergent and was used at 1% in water.

Counts were made of the number of live nettle grubs present on five leaves, selected at random, per bush, making a total number of leaves examined per plot of 125. A count was made just before spraying (precount) and at five days and fourteen days after spraying; after this time, all grubs had pupated.

TABLE 2.—*Results of Experiment 2 on chemical control of nettle grubs*

TREATMENT	No. of living larvae per 500 leaves (100 bushes)		
	Precount	After 5 days	After 14 days
Malathion 0.2%	163	24 (S)	1
DDT Wettable Powder 0.2% ...	279	32 (S)	8
DDT emulsion 0.1%	166	16 (S)	3
Teepol 1%	169	127 (S)	48
Untreated control	187	152	69

(S) = sprays repeated after five days.

The results confirmed that Teepol was of little value, and malathion and both formulations of DDT were promising, and gave a more rapid kill than had previously been obtained by the use of the wilt virus. It will be noted that the number of grubs in the untreated plots was less after five days, and again after fourteen days, than was initially recorded in the precount. A similar decline in numbers will later be noted in the results recorded for other experiments recorded in Table 3 and 4. It is apparent that usually a large number of grubs do not reach maturity; where the population of very young grubs is as great as ten or more per leaf, as is frequently

the case in an outbreak, this could be caused by starvation due to over-crowding, although the reason for it when the numbers are lower (as in Table 2)is not apparent. It was not, in any of the instances recorded in Tables 2—4, due to insect parasites or wilt disease. However, any experiment on nettle grub control is likely to record declining numbers within the span of a single generation, but the severity of the foliage damage does not usually decline. On the contrary, older grubs eat a great deal more and the bushes are often devoid of foliage by the time they have matured.

Further work on chemical control was concentrated upon the use of DDT in emulsion formulations, which are likely to be more economical in use than wettable powders. It was hoped in 1960 to carry out a large scale experiment comparing the use of the wilt virus and DDT. Unfortunately, the occurrence of wilt in the field in 1960 was very slight, and attempts to produce a sufficient quantity by artificially spreading the disease amongst grubs in the laboratory were not successful. Consequently, when large-scale outbreaks occurred in Uva in 1960, the opportunity was taken to test further the value of DDT on a large scale.

In experiment No. 3, carried out on an estate in the Badulla district, a trial was arranged with the Superintendent, in which an area of 18 acres of tea was divided into four quarters of 4½ acres each. Two of these were sprayed with DDT emulsion at two different rates; the remaining two quarters were left unsprayed for comparison. DDT was used as a 25% emulsifiable concentrate (E.C.) formulation at 3 pints in 70 gallons of water per acre (approx. 1 lb DDT/acre) on one plot, and at 6 pints in 70 gallons of water per acre (approx. 2 lb DDT/acre) on the other. These rates were repeated after nine days. Spraying was done with pressurized knapsack sprayers. Counts were made of the number of living grubs on two leaves per bush on fifty bushes distributed across each plot, making a total of 100 leaves per plot. Counts were made initially before spraying (precount) and nine days and twenty-four days after spraying. The results are given in Table 3.

TABLE 3.—*Results of Experiment* 3 *on chemical control*

TREATMENT	No. of living larvae per 100 leaves (50 bushes)		
	Precount	After 9 days	After 24 days
DDT (emulsion) 1 lb./acre	564	35 (S)	0
DDT (emulsion) 2 lb./acre	563	0 (S)	0
Untreated control	562	297	198
Untreated control	1200	334	247

(S) = sprays repeated after nine days.

This experiment demonstrated a very promising effectiveness of DDT on a large scale, and even one application of the lower dosage rate of 3 pints of the 25% emulsifiable concentrate (E.C.) in 70 gallons of water per acre appeared to be fairly adequate. It was known that it is often a problem on many Uva estates to find sufficient water for spraying in the dry weather, when nettle grubs usually occur. For this reason the opportunity was taken when a further outbreak occurred at an eatate near Hali-Ela to try the effect of applying the same dosage rates of DDT per acre in very much smaller volumes of water with a motorised knapsack mist blower. With the co-operation of the Superintendent, an area of 12 acres in a field badly attacked by young Nettle Grub was divided into four quarters, two of which were left as unsprayed controls. Half of each sprayed plot was treated at low-volume using a motorised knapsack mist blower, and the other half at the normal volume applied by conventional knapsack sprayers. The details of the treatments were as follows;—

Plot A1 (1½ acres) 6 pints DDT (E.C.) in 4 gallons water per acre (= 2 lb DDT/acre), by mist blower.
Plot A2 (1½ acres) 6 pints DDT (E.C.) in 70 gallons water per acre (= 2 lb DDT/acre), by knapsack sprayers.
Plot B (3 acres) Untreated.
Plot C1 (1½ acres) 3 pints DDT (E.C.) in 4 gallons water per acre (= 1 lb DDT/acre), by mist blower.
Plot C2 (1½ acres) 3 pints DDT (E.C.) in 70 gallons water per acre (= 1 lb DDT/acre), by knapsack sprayers.
Plot D (3 acres) Untreated.

Counts of live grubs were carried out as in Experiment 3. The results are recorded in Table 4.

TABLE 4.—*Results of Experiment 4 on chemical control*

PLOT	TREATMENT	No. of living larvae per 100 leaves (50 bushes)	
		Precount	After 8 days
A1	DDT, 2 lb./acre, low volume	1090	0
A2	DDT, 2 lb./acre, high volume ...		0
B	Untreated control		318
C1	DDT, 1 lb./acre, low volume	998	0
C2	DDT, 1 lb./acre, high volume ...		0
D	Untreated control		138

As in the previous large-scale experiment an extremely good control of Nettle Grub was obtained and the kill was rapid. No living grubs were found on any of the 4 treated plots when first re-examined after eight days, whilst a heavy infestation continued to do severe damage on the untreated plots. In these circumstances, the Superintendent sprayed these plots shortly afterwards, with successful control, and no further counts were made.

Discussion

Considerable caution is necessary in the use of insecticides on tea. They should be chemicals of a low human toxicity, so that the spraying labourer can use them as recommended without danger to health. They should not themselves cause any damage to the plants. If used on tea in plucking, they should not taint the made tea, and if any residues of the insecticide are present in the made tea these should be harmless to the consumer. In these respects, DDT is one of the safest insecticides for the spraying labourer to use, is non-phytotoxic, and has been shown to cause no taint in the made tea even in gross dosages. The question of residues in the made tea is being studied; this work will be reported elsewhere, but meanwhile it does not look as if there will be any serious deterrent to the use of DDT on these grounds.

The first criterion in judging whether or not to use an insecticide is that it should be profitable to apply the treatment. With many pests this is far from easy to judge, and data on crop losses caused by the pest are often hard to obtain. However, in the case of a nettle grub outbreak which is liable to defoliate many acres of tea, the case is clear-cut. The cost of treatment with DDT is small *e.g.*

3 pints of a 25% DDT emulsion at Rs. 16/- a gallon	Rs. 6.00
3 labourers per acre, to spray at 70 gallons per acre ...	Rs. 6.75
Total cost per acre ...	Rs. 12.75

If we are able to do the low-volume spraying by motorised knapsack mistblower, two labourers should be able to spray at least six acres per day with one machine, and the cost per acre for labour is 75 cents, and for petrol 50 cents; making a total cost of Rs. 7/25.

Thus there is no question of the profitableness of treatment provided the use of DDT does not run us into other difficulties. This is the remaining reason for caution, based on the fact that insecticides not infrequently, but by no means always, have undesirable side-effects on the balance of insect populations—of pests and parasites—on a crop, so that some species, previously present in harmless numbers, becomes numerous and pest. This is of particular importance on tea, which as a perennial crop covering large areas, supports a large variety of potential pests, and their parasites and predators, at low population levels. Very few artificial measures at present interfere with this balance of populations.

However, the local and infrequent use of insecticides on the tea crop, which is all that is required, is a very different thing from the overall treatment of a crop, for the reason that if the balance of nature is upset on a few acres, this *may* be quickly restored by immigration of insects from the surrounding untreated areas. One of the most commonly recorded side-effects of DDT is an increase in mite populations. This has happened on several crops in many countries, and therfore we should look closely for such an effect on tea. So far, although DDT has been used locally on tea on several occasions during the last few years, no such effect has been proven. In one instance only, there appeared to be an increase in Tea Red Spider (Austin, 1958), but in several other instances no increase of mites was observed. This aspect is now under close investigation.

If it is shown that DDT is not generally liable to have this effect or other undesirable side-effects, there can be no objection to its use on tea. If used on tea in plucking, certain restrictions may be necessary to prevent or minimise residues in made tea. No general recommendation can yet be made.

The artificial use of the wilt virus is also a possible means of control, but in order to supply a virus suspension to estates in sufficient quantity, the T.R.I. would have to establish a special unit for the purpose. This could be done, but the cost per acre would almost certainly be greater than the cost of DDT, and it is clearly not desirable unless the use of insecticides is proved to be unwise.

Summary

1. An account is given of the biology of the Fringed Nettle Grub (*Macroplectra nararia* Mo.) and of factors in the natural control of the pest, including wilt virus disease.

2. In a small plot experiment, a suspension of wilt virus, made simply by macerating diseased grubs in a 0.2% blood albumen suspension, was sprayed over bushes infested with nettle grubs. This started an epidemic of the wilt disease which greatly reduced the numbers of the grubs within two to three weeks. Some of the foliage damage caused by the grubs was prevented but the speed of action of the virus was slow. There was no evidence of the virus persisting on the foliage to affect a later (second) generation of nettle grubs which developed six weeks after spraying.

3. Three field experiments on the use of insecticides are reported. In a small scale replicated trial, 1% Teepol gave virtually no control. DDT at 0.1% (emulsion) and 0.2% (wettable powder), and malathion at 0.1% (emulsion), gave good control. Two field-scale trials with DDT emulsion gave excellent results with a rapid kill of grubs. 1 lb actual DDT per acre in emulsion form appeared to be adequate; this was successfully applied in 70 gallons of water per acre by knapsack sprayers and in 4 gallons of water per acre by motorised knapsack mistblower.

4. Factors in the use of DDT on tea are discussed; no general recommendation for use on tea can yet be made.

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THE INFLUENCE OF THE SOIL ON THE DEVELOPMENT OF PLANT DISEASES AND PESTS

D. Mulder

The development of plant diseases and pests depends not only on the plant, the parasite, and the climate, but also on the soil. The soil is not merely an inert material containing minerals that feed the plant; it is itself very complex and it carries a community of very varied organisms.

The basis of life for the micro-organisms in the soil is the organic matter that is produced by plants through the process of photosynthesis. Photosynthesis is the process by which green plants (with the pigment chlorophyll) use the energy of sunlight to transform carbon dioxide and water into simple sugars, which are then, together with mineral nutrients from the soil, transformed into complex assimilation products which the plant can use or store. Thus the plant needs minerals from the soil and also water.

Decaying plant material serves as food for a large number of bacteria, saprophytic fungi, and eelworms, upon which certain other species prey.

The microflora and microfauna of the soil are of such complexity, and the number of species of organisms involved is so big, that a complete analysis of life in the soil is practically impossible. One thing, however, is clear, namely that just as in communities above the soil surface, most organisms live at the expense of other organisms and rely for their food on the presence of those other species; the only exceptions are the green plants, which eventually provide for all the other species. All organisms in the soil affect each other in some way or other; either by competing for minerals and water, or by devouring each other, or by hindering each other in their growth by secreting substances in the soil that are harmful to other organisms. By these means all micro-organisms in the soil are kept in check and cannot monopolise food sources. Thus, in natural soil, a balanced life of different micro-organisms is established. Any change in the vegetation also causes a change in these balances. With a decrease in vegetagion due to cultivation the amount of organic matter in the top soil decreases, and the numbers of saprophytic organisms, which live on this dead organic matter decrease to the advantage of plant parasitic organisms that were earlier hindered in their growth by saprophytes. If we apply these principles of soil microbiology to the cultivation of tea then we find that the composition of the soil can affect, among others, the following processes:

(1) root diseases and their spread are influenced by the antagonistic action of antibiotics produced by saprophytic fungi;

(2) the number of plant-parasitic eelworms can be influenced by the presence of predatory fungi and predatory eelworms;

(3) leaf spot diseases can be influenced by certain antagonistic organic compounds, produced by organisms in the soil and taken up by the roots, which hinder the development of the parasite in the leaf;

(4) the growth of the fungus, which serves as food for the larvae of the Shot-hole Borer, may possibly be influenced by the antagonistic action of antibiotic products of saprophytic fungi in the soil, if these products are absorbed by the wood on which the fungus lives. This is not proven but may well be so.

These four processes will be markedly affected by the organic-matter content and the microflora of the soil.

Plants can be very roughly divided into two groups, the extremes of which are those which can grow on virgin soil and have pioneer characteristics, and those which normally flourish in a well developed general vegetation, preferably a forest, so that they grow in a rich organic soil with a fully developed microflora. The latter group is probably dependant for healthy development on a soil rich in organic matter. The natural habitat of the tea plant is in the shade of a sub-tropical forest, so it belongs to the latter group.

The soil of a well-tended tea estate up country contains as much organic matter as the soil of the nearby jungle, but in the mid-country, the organic matter is less (Tolhurst 1956; Ramaswamy 1960). The effects of this change in environment have never been studied, but from what we know about other crops and other soils certain things can be deduced, and conclusions drawn as to the probable effects.

1. Root diseases caused by parasitic fungi

The parasitic fungus spreads from a diseased root to a healthy root by growing through the soil. During this growth through the soil it is influenced by the substances present in the soil water, particularly by substances secreted by saprophytic fungi as products of their metabolism, which can have an inhibiting influence. One of these saprophytic fungi is *Trichoderma viride* (Weindling and Emerson, 1936). It has been found in the laboratory that the secretion products of this fungus have a marked inhibitory effect on the growth of *Poria* in the soil (Mulder, 1960).

Other fungi that can be inhibited in a similar way are: *Ustulina*, *Fomes* and *Armillaria*. It is less likely that *Rosellinia* will be influenced by *Trichoderma* to the same extent, because *Rosellinia* is able to grow profusely as a saprophyte on leaf litter lying on the soil surface.

Application of this principle of antagonism to practical problems is, however, still rather remote, because it is not easy to increase the quantity of *Trichoderma* in the soil. Injection of *Trichoderma* spores would not help, because they are probably always present and their success depends on soil conditions (mainly the quantity of organic matter present as food for the fungus) and cannot therefore be increased by artificial introduction of the fungus.

2. Eelworm diseases

The eelworm population in the soil consists of saprophagous, predatory and plant parasitic eelworms. In a soil rich in organic matter, the saprophagous eelworms will be numerous, with the parasitic eelworms forming only a minor part of the total population of eelworms.

One group of fungi lives as predators on living eelworms by catching them with special trap devices formed by sticky knobs or rings of mycelium (Duddington, 1955). These fungi can live saprophagously on organic matter and they only develop their trapping equipment where there is a substantial total eelworm population. If eelworms are absent or few, the fungi preying on eelworms do not develop their

trapping devices and can consequently not reduce the number of parasitic eelworms. If there is a large total population of saprophagous eelworms due to presence of organic matter, the number of predatory eelworms also tends to increase and these can also reduce the number of parasitic eelworms. There can, therefore, be other reasons why cattle manure has a beneficial effect on plants which suffer from eelworm attack, in addition to the beneficial effect on plant growth.

3. Leaf-spot diseases

Fora long time it has been held that the plant takes up only water and mineral salts from the soil through its roots. It is now, however, becoming clear that, together with water and minerals, certain soluble organic substances can penetrate the root surface and enter into the vascular system of the plant.

For instance, antibiotics can be taken up by the roots and be transported to the leaves through the wood (Brian, 1956). These antibiotics can influence the susceptibility of the leaves to certain parasitic diseases (Mitchel, Zaumeyer and Preston, 1953). A number of saprophytic soil fungi produce antibiotic substances and there is no doubt that these antibiotics will be taken up by the plant from the soil (Hamilton and Szkolnik, 1958).

4. Shot-hole Borer

The female beetle carries with her the spores of the fungus *Monacrosporium ambrosium* (ambrosia fungus) (Fernando, 1959) and every gallery which this beetle bores is infected with this fungus. The larvae, which hatch from eggs laid in these galleries, feed on the threads and spores of this fungus. The fungus is essential for the development of the borer. If we could eliminate or reduce the growth of *Monacrosporium* the development of the Shot-hole Borer would be affected. This might be achieved if the wood, on which the fungus feeds, contained substances toxic to the fungus.

The development of systemic fungicides, (*i.e.* fungicides absorbed and translocated by the plant) is still in its infancy; so far, the only ones which show promise are some antibiotic substances produced by Actinomycetes and a few synthetic chemicals.

It may be that antibiotics produced by fungi in the soil are taken up in the wood, and present in the wood in sufficient concentration to impair the growth of the ambrosia fungus. If this is indeed the case then we ought to find a relation between the type of soil and the occurrence of Shot-hole Borer. The speed of growth of the wood should also influence the growth of the fungus, because, the faster the growth, the lower the concentration of the antibiotic substances in the wood may be, and the better the growth of the fungus. The best manured tea is often heavily attacked by Shot-hole Borer.

Reviewing these considerations, we can state a principle that underlies the difference between the circumstances of natural vegetation and modern agricultural cultivation: if we reduce the number of organisms at one point in the chain of biological processes, the balance in the rest of the chain will be upset and outbreaks or epidemics, due to abnormal multiplication of one organism, then called a pest or disease, will develop.

We cannot turn back the developments of intensive agriculture, but we can try to adapt our cultural measures as far as possible to meet the needs of other organisms that play a part in maintaining or restoring the 'balance of nature'. This can be of particular importance on a perennial crop such as tea.

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MOTORISED KNAPSACK MISTBLOWERS

A. L. Elias

Spraying of copper fungicides against Blister Blight was carried out at St Coombs estate on a large scale using five makes of shoulder-mounted motorised mistblowers. Spraying commenced at the beginning of May, 1960 and continued throughout the height of the south-west monsoon up to the middle of August—a period of roughly 15 weeks.

The following makes of mistblowers, which were supplied for trial by their respective agencies, were used:—

'Motoblo' 1959 model	(United Tractor & Equipment Ltd.)
'Kohoo'	(Shaw Wallace & Hedges, Ltd.)
'Hurricane'	(Shaw Wallace & Hedges, Ltd.)
'Boss'	(Chatham House Ltd.)
'Micronizer 26'	(A. Baur & Co. Ltd.)

These machines differ in certain features but all gave satisfactory performance during the period of test. We have not carried out thorough machine tests, and we do not yet know the life of these machines under local conditions.

Blister-Blight Control

In July and August, fields sprayed with mistblowers were assessed for blister-blight infection by the Plant Pathologist. Fields sprayed with conventional knapsack sprayers were also assessed at the same time. Protection was found to be at least as good in fields sprayed with mistblowers as in fields sprayed with conventional knapsack sprayers.

Coverage

Observations showed that the fine droplets were evenly spread on the flush and on the upper surfaces of the mature leaves for 6—8 rows of bushes on either side of the spraying labourer, *i.e.* 12—16 rows of tea at one spraying. When winds were particularly strong there was some reduction of this area.

Manoeuvrability

There was some difficulty of movement on very steep terrain and in tea over $2\frac{1}{2}$ years old. Fields recovering from pruning were sprayed effectively without the slightest difficulty.

Costs

Labour, cost of spraying @ Rs. 2/37 + 40 cents extra rate	.40 cts p. acre
Cost of fungicide @ 4 ozs per acre (Rs. 1/80 per lb)	.45 „ „
Cost of petrol and oil	.20 „ „
Cost of tea and clothing for sprayers etc.	.10 „ „
Rs.	1.15 per acre

This should be compared with Rs. 1/80 per acre on St Coombs for conventional knapsack spraying.

Tasks

A team of three labourers operating two motorised knapsack mistblowers sprayed 21 acres per day, *i.e.* 7 acres per labourer or 10½ acres per machine. The actual working period per day was five hours. One labourer mixed the fungicide and was in charge of running repairs. A change-over on the actual operation of the machine was found to be desirable. The team therefore acquired sufficient all-round knowledge regarding manipulation and maintenance.

Labour Reaction

Contrary to expectations, labourers reacted extremely satisfactorily and protection of a high order was maintained throughout. A team of labourers were handed two machines and told that the maintenance and upkeep of these machines was their responsibility. There were no complaints regarding excessive noise, weight or vibration.

Quantities of Fungicides

The mixture of 4 ozs copper fungicide (50% wettable powder) in 2 gallons of water was found to be adequate and effective for protection against Blister Blight under adverse weather conditions. It is desirable to have polythene packets containing 4 oz of the fungicide packed beforehand and a 2-gallon watering can for mixing purposes. Straining should be done at all times. One gallon of petrol-oil mixture was sufficient for the machine to spray approximately 21 acres. A full tank (2 gallons) of fungicide in these machines lasted about 15—20 minutes at the output setting we used. For tea recovering from pruning, 6 ozs fungicide in 2 gallons of water per acre is recommended.

Initial outlay

An estate spraying approximately 1,000 acres of young tea per month will re-cover the initial cost of one machine in savings in about two months. The cost of these machines varies from Rs. 750/- to Rs. 1100/- each.

Weights

The weight of the machines used varied from 28 to 40 lb empty, or from 54 to 66 lb when loaded with 2 gallons of spray.

Conclusions

Using the usual amount of fungicide (4—6 oz) in 2 gallons water per acre, mistblowers gave excellent coverage and at least as good blister-blight control as when using conventional knapsack sprayers at 15 gallons water per acre. The overall cost of spraying was Rs. 1/15 per acre for mistblowers, compared with Rs. 1/80 per acre for knapsack sprayers, capital expenditure excluded. With saving of this order, the initial outlay on the mistblower machines can be paid off in a short time.

Acknowledgments

I acknowledge, with thanks, figures given by the Pathology Division on blister-blight counts taken by them on fields sprayed by mistblowers and by conventional knapsack sprayers.

Thanks are due to Messrs. United Tractor & Equipment Ltd., Messrs Shaw Wallace & Hedges Ltd., Messrs Chatham House Ltd., and Messrs A. Baur & Co. Ltd., for the loan of machines which made this work possible.

LETTERS TO THE EDITOR

CONTROL OF SHOT-HOLE BORER WITH DIELDREX

Shot-hole Borer of Tea (*Xyleborus fornicatus* Eichhoff) is the most damaging insect pest in mid-country estates, and for many years various methods of control have been tried with little success.

In 1955 I was approached by Dr B. A. Baptist, then of the Tea Research Institute, for permission to conduct small-scale experiments on Sanquhar Estate for the control of Shot-hole Borer. Permission was readily given and three blocks of two acres each in young tea fields were sprayed after pruning with four applications of "Dieldrex 15"; about 70 gallons per acre of a 1 in 200 dilution was used for each application. (*i.e.* a total of 2. 1 lb actual dieldrin per acre altogether)

In Block 1 (1948 planting), the four applications were given at three-weekly intervals, the first application being two days after pruning. The later applications were made after new growth had appeared and at the tipping stage. A severe attack of Tortrix occurred, lasting about 2½ months.

In Blocks 2 and 3 (1950 and 1952 plantings respectively), the applications were given at weekly intervals, starting two days after pruning. In these blocks the last application was given at bud-break time; very little Tortrix was noted on these blocks.

From time to time, T.R.I. Assistants visited these plots and took counts of re-infestation, but yield records were not at first made for these experiments.

In April 1957, Block 3, which at that time was on a two-year cycle, became due for pruning, and more from curiosity than anything else, I collected several new growth branches from the area and also some from an unsprayed area. These I split and found that the branches from the sprayed area had far fewer attacks (galleries) from Shot-hole Borer than those from the unsprayed area; many from the sprayed area were free from attack.

At this time Dr Baptist had left the T.R.I. and Mr G. D. Austin was Acting Entomologist. At his request, I sent him branches from the sprayed and unsprayed areas. He reported that 225 branches from the sprayed area contained 135 borer galleries; 225 branches from the unsprayed area contained 878 galleries.

I was so impressed with these results that I started a yield experiment in Blocks 1 and 2 which were on a 3-year pruning cycle. I obtained permission to carry out a further experiment on 3 acres of old tea, which I gave 3 applications of "Dieldrex 20", using 2 pints of the insecticide in 60 gallons of water per acre per application (*i.e.* a total of 1.5 lb actual dieldrin per acre); the 3 applications were given within one month of pruning. This experiment consisted of 9,000 bushes in field No. 15 planted in 1903 and was compared against 9,000 untreated bushes as a control alongside the sprayed area. From the start of the yield tests, the sprayed areas showed a marked increase in crop over the control area.

So far, in 138 plucking rounds from November 1957 to September 1960, the green leaf weights from the sprayed and unsprayed plots are as follows:—

9,000 bushes sprayed	41,499 lb.
9,000 bushes unsprayed	33,588 lb.
Increase ...	7,911 lb.

This represents, at 3,000 bushes per acre, an increase of 2,637 lb. green leaf or 600 lb. made tea per acre for the period of 34 months.

Large-Scale Spraying

In 1958 I was given permission to spray all pruned fields in the future. This has been done at the rate of 4 pints per acre (1 lb of dieldrin) until the beginning of this year. My Visiting Agent decided to stop spraying for a period of one year to allow the population of the Tortrix parasite, *Macrocentrus homonae*, to build up. We have now started to spray 'Dieldrex' again.

Usually, two applications of 2 pints "Dieldrex Extra" in 60 gallons water are given, one after pruning and the other before bud-break. But I have done variations of this method of application, *i.e.* giving the full 4 pints of "Dieldrex" in one application, using 80 gallons of water, also spraying only the bottom half of the bush frames after pruning and just prior to tipping. It is too early yet for me to state whether any one method is better than the other.

The cost of applying the two applications of the spray mixture, inclusive of labour employed to heap the prunings to facilitate spraying, works out at between Rs. 37/50 and Rs. 40/- per acre; all bushes are thoroughly dowsed with the solution, especially around the trunk of the bush.

During this last month, I have examined branches (new growth) from two fields sprayed in July-August 1958 and from two fields pruned in 1958 but unsprayed; for this purpose I examined one foot lengths, taken from the bottom part of the branch. The results are shown in Table 1.

TABLE 1.—*Sanquhar Estate—Branch Infestation Counts*

Field No.	No. of branches examined (1-foot lengths)	No. of branches affected	No. of galleries found	Date of pruning
8 (Treated)	50	11	14	July-August 1958
24 (Treated)	50	8	11	July-August 1958
14 (Untreated) ...	50	46	264	February-March 1958
18 (Untreated) ...	50	50	342	March-April 1958

In Table 2, I compare the yields of sprayed and unsprayed fields against their previous cycle yields. I have tried to make the comparison with the previous cycle as fair as possible by taking periods from pruning during which the manuring rates were very similar. No unsprayed fields are less than two years from pruning, because no pruned fields were left unsprayed in 1959. It should be noted that Field No. 25, pruned in November-December 1958, suffered very badly from the drought experienced in 1959 and tipping was delayed for two months. Also Field 21 was badly attacked by Tortrix and up to the 14th month the yield was behind the previous cycle. At the 16th month it was equal and this field is now yielding over 140 lb. per acre per month; this is a good example of how, despite Tortrix attacks induced by dieldrin, the long-term result may be good.

TABLE 2.—*Sanquhar Estate—Yield comparison*

Field No.	Year of planting	No. of months after pruning	Yield this cycle from pruning	Yield last cycle for same period from pruning	Average increase per annum to date
Sprayed Fields (this cycle; unsprayed last cycle)					
No. 8	1907	22	2,406	1,861	297
No. 24	1951	22	1,787	1,259	288
No. 25	1951	20	1,393	1,225	101
No. 20	1949	17	1,181	912	190
No. 21	1949	at 14	788	916	—110
		at 16	1,079	1,073	4
No. 23	1952	17	1,124	866	184
No. 26	1952	12	989	747	241
Unsprayed Fields					
No. 2	1895	22	841	801	22
No. 3	1896	22	1,010	1,030	— 11
No. 14	1937	29	1,889	1,703	77
No. 18	1948	22	1,434	1,236	108
No. 19	1948	24	924	909	7½
No. 22	1950	27	1,452	1,193	115

Here on Sanquhar I have found that Tortrix usually starts to appear just before the tipping stage and comes gradually under control by its parasite within two to four months, depending on the severity of the attack. Only once has Tortrix lasted more than four months; but in spite of this attack the field affected yielded 236 lb. per acre more than any other field in its Division. This year I intend to experiment on one field of 30½ acres by spraying DDT at the tipping stage to knock out the Tortrix; it will be interesting to see whether Tortrix or the parasite *Macrocentrus homonae* gains control first thereafter.

I have found that Tortrix attacks are usually more severe on fields sprayed in July, August and September, than on fields sprayed in March, April, May, October and November.

Recently I have noticed that in fields sprayed in 1958, the bushes near the perimeter of the field, adjoining unsprayed tea, have more Shot-hole Borer than bushes further in towards the centre. Examinations by Mr J. E. Cranham, Entomologist, T.R.I., have, I believe, confirmed this. This leads me to believe that the borer will move in again from the edges of the sprayed area, and consequently large-scale spraying may give longer protection than the treatment of single fields. It is quite possible that in sprayed fields surrounded by other sprayed fields the control obtained may last for two or more pruning cycles; this remains to be seen.

In conclusion, I am convinced that protecting tea against Shot-hole Borer attack either with Dieldrex or other suitable insecticides is absolutely essential if estates affected by this pest are to be maintained at the high level of production necessary to run them economically.

I take this opportunity of thanking those officers of the Tea Research Institute who have helped me from time to time to in carrying out this very interesting work; also the Shell Co. of Ceylon Ltd., Colombo, who have given me every assistance and information regarding 'Dieldrex', and the Shell International Chemical Co. Ltd., U.K., for having carried out tests for residues of the insecticide dieldrin in green leaf and made tea from fields sprayed after pruning with "Dieldrex".

A. P. NEWTON
Superintendent

Sanquahar Estate,
Atabage.
5th October 1960.

POWER CHARGE PUMPS

A minority of estates appear to have experience with motorised pumps for charging pneumatic knapsack sprayers with both air and spray liquid.

The "Vitiver" charge pump is one such unit suitable for charging "Favori-Colibri" or other knapsack sprayers and has been used on St Coombs Estate since 1953, and the following details may be of some interest to other estates.

This unit will charge six sprayers simultaneously with liquid to 170 lb per square inch, *i.e.* $2\frac{3}{4}$ gallons for each sprayer, in under 2 minutes.

The compressor charges a container with 45 lb of air in approximately two minutes or to 70 lb in a rather longer time. The initial charge of air is retained for a day or more. It is an advantage if multiples of six sprayers are employed and up to 48 can easily be maintained.

Owing to its greater mobility and quick charging potential, between 3-4 acres can be completed per labourer per day. The dosage rate has varied between 4—6 ozs of copper fungicide in 15 gallons of water per acre. In extremely adverse weather, 8 ozs copper fungicide has been used.

The "Favori-Colibri" knapsack sprayers used on St Coombs were fitted with OC-O2 Boomjet nozzles. The total overall cost during 1959 was Rs. 2/33 per acre sprayed. This includes labour, tea, sugar and milk, overtime to tractor driver and cost of transporting equipment, petrol, engine oil, cotton waste, etc. and the cost of fungicide.

It is important that proper organization of water points in each field and suitable roads are available to ensure success.

The "Vitiver" charge pump has worked well for the past seven years without major breakdowns. The unit is still in excellent condition, having been serviced and overhauled each year during the dry weather.

A. L. ELIAS
Superintendent

St Coombs Estate,
Talawakele.
25th October, 1960.

SUMMARY MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON, HELD IN THE GENERAL COMMITTEE ROOM OF THE PLANTERS' ASSOCIATION OF CEYLON, COLOMBO, ON FRIDAY, 2nd SEPTEMBER, 1960.

Present.—Messrs F. Amarasuriya (Chairman), R. A. G. McMichen (Chairman, Agency Section, Planters' Association of Ceylon), H. E. Peries, O.B.E. (Deputy Secretary to the Treasury), B. Mahadeva, C.C.S. (Tea Controller), E. Muttukumaru (Chairman, Low Country Products Association), A. V. Richards (Acting Director of Agriculture), J. D. Weerasekera, M.P., R. J. Gilmour, R. D. Wedd, J. L. D. Peiris, E. Jayawickreme, D. E. Hettiarachchi, C. R. Webber, Dr D. L. Gunn, C.B.E. (Director, T.R.I.), Messrs G. A. D. Kehl (Administrative Secretary, T.R.I.) and H. J. Balmond (Secretary).

Messrs R. C. Scott, C.B.E., and N. M. Sanders intimated their inability to attend.

1. Minutes of the Meeting of the Board held on 3rd June, 1960

The minutes were confirmed.

2. Matters Arising out of the Minutes

(1) Mid-country Clonal Station.—Reported that the lease agreemnets were being prepared and it was hoped to make an early start on the construction of the buildings. The report was received.

(2) Instant Tea.—Reported that the minutes of the first meeting of the Economic Committee for Instant Tea had been circulated for the information of the Board (Paper EC. 9/60). The minutes were received.

3. Membership of the Board & Committees

(a) Membership of the Board.—The Board received the following reports:—

Mr R. A. G. McMichen had become an *ex-officio* member of the Board as Chairman of the Agency Section of the Planters' Association of Ceylon *vice* Mr G. I. de Glanville, with effect from 15th July, 1960.

Mr R. M. Macintyre was on four months' leave and no appointment had been made in his place by the Planters' Association.

Mr J. D. Weerasekera, M.P. for Kotmale, had been nominated by the Minister to represent the House of Representatives for a period of three years as from 6th August.

(b) Appointments Committee.—Mr R. D. Wedd was nominated to the Appointments Committee in place of Mr G. I. de Glanville.

The Chairman thanked the outgoing members for their services, and welcomed the new members.

4. Finance

(1) Auditors report and audited accounts for the year ending December 31st, 1959.—The audited accounts of the Institute including the Junior Staff Medical and Provident Fund accounts as at 31st December, 1959, and the auditors report thereon, together with the auditors report on St Coombs Estate accounts, which had been circulated as Paper B. 43/60, were tabled for adoption.

Reported that the audited accounts and the auditors' reports had been examined in detail by the Administrative Committee at its meeting held on 22nd July, 1960.

On the proposal of Mr Gilmour, seconded by Mr McMichen, the Board adopted the audited accounts as at 31st December, 1959, and the auditors report thereon.

(2) Institute's accounts and Estate working account as at 31-7-60.—The Board adopted the Institute's accounts and the Estate working account as at 31st July, 1960. The Board approved the following Supplementary Estimates:—

(a) Estate.—(i) INFECTIOUS DISEASES WARD.—Rs. 5,225 for building an infectious diseases ward.

(ii) C.F.I.A. REQUIREMENTS.—A token vote to meet costs of implementing C.F.I.A. recommendations regarding the factory.

(b) Engineering department.—(i) ROADS—GENERAL VOTE.—Rs. 6,000 to meet expenditure on roads for the rest of the year including metalling of a new road to the 4 new Junior Staff quarters.

(ii) ROADS—SPECIAL VOTE.—Rs. 5,510 to meet the cost of constructing a road to the Superintendent's new bungalow.

(iii) SUPERINTENDENT'S NEW BUNGALOW.—Rs. 2,800 to meet cost of constructing a retaining wall.

(iv) EQUIPMENT.—Rs. 3,960 for the purchase of one hydraulic tipping trailer for dumping earth from new building sites and also for use next year for refuse disposal.

(v) MATTAKELLE—RADELLA ROAD.—Rs. 1,600 for repairs to this road which was used by the T.R.I. staff. Reported that The United Planters' Company had agreed to contribute an equal sum of Rs. 1, 600 towards the maintenance of this road.

The Board received the report and recorded its appreciation of the action of the United Planters Company.

5. Minutes of the Administrative Committee Meeting held on 22nd July, 1960, and Financial Appendix

The minutes of the Administrative Committee meeting held on 22nd July, 1960, which had been circulated to the Board (Paper SC. 44/60) were tabled for discussion and adoption.

(1) Page 6.—Reported that the Buildings Committee had visited the Minor Staff quarters and the Dhoby's quarters, and had recommended the approval of the votes of Rs. 2,200 for additions to the Dhoby's quarters, and Rs. 5,250 for improvements to the minor staff quarters. The report was received.

(2) Page 9.—Tenders for new Junior Staff quarters.—Reported that new tenders had been invited in accordance with the instructions of the Administrative Committee. The report was received.

The Board then approved the minutes of the Administrative Committee meeting held on 22nd July, 1960.

6. Minutes of the Appointments Committee Meeting held on 21st July, 1960

The minutes were tabled for discussion and adoption.

(1) Post of Statistician.—The Board approved the recommendation that Mr P. Kanapathipillai be appointed to the post of Statistician.

(2) Post of Agronomist.—The Director reported that Mr H. N. Hasselo had expressed his willingness to accept appointment on the terms offered and intended assuming duties on April 30th, 1961. The report was received and the Board approved the appointment.

The minutes of the Appointments Committee were then adopted.

(3) Intermediate Staff.—The Director reported that the Selection Committee had recommended that the following be offered appointments:—

Research Assistant in Entomology—Mr W. Danthanarayana.

Research Assistant in Nematology—Mr P. Sivapalan.

Librarian—Mr D. J. de S. de Silva.

The Board approved the recommendations and noted that no suitable candidates were available for appointment as research assistants in Agricultural Chemistry and Biochemistry and that these posts were being re-advertised.

7. Minutes of the Meeting of the Experimental and Estate Committee held on 5th August, 1960 and Financial Appendix

The Board adopted the minutes and approved the following financial recommendations:—

(1) Minute 4.11. Ecologist.—Financial provision be included in the 1961 estimates for the appointment of an Ecologist.

(2) Minute 5.1. Air-heating machinery in the factory.—Rs. 5,463/- be provided for repairs to the Marshall's Empire 3 ft. drier subject to availability of the necessary parts in Ceylon and inclusive of estate commitments.

(3) Minute 5.2. Wilken's trough witherer.—Rs 2,000/- be provided in the 1961 estimates for the installation and testing of this equipment.

8. Tea Research Institute Ordinance—Amendments

The proposed amendments which had been circulated were tabled for discussion and adoption.

After a full discussion the Board approved the amendments subject to a further amendment in paragraph 5 to ensure that the auditors would report direct to the Board.

9. **Staff Matters**

(1) Salaries Committee.—Matters relating to salaries and conditions of service were discussed and the Board appointed a sub-committee consisting of the Chairman of the Board, the Chairman of the Agency Section of the Planters' Association, the Director, T.R.I. and Messrs J. L. D. Peiris, R. J. Gilmour and E. Muttukumaru, with powers to co-opt, who would examine the relevant data and recommend in the first instance terms of reference for the approval of the Board.

(2) Appointments to Junior Staff grades.—

Mr S. Calnaido—Junior Tecnical Assistant Grade II, (Entomology, Shothole Borer) with effect from 21-6-60.

Mr M. B. Palies—Stores Costing Clerk, Junior Staff Grade II, with effect from 5-4-60.

Mr H. M. R. Bandara—Clerk-Typist, Junior Staff Grade II, with effect from 3-7-60.

Mr T. R. B. Sally—Clerk-Typist, Junior Staff Grade II, with effect from 11-7-60.

Mr S. Kulasabanathan—Clerk-Typist, Junior Staff Grade II, with effect from 1-8-60.

(3) Resignations.—

Mr R. A. Jayatilleke—Research Assistant in Nematology, with effect from 30-8-60.

Mr D. C. W. T. Amarasingha—Stenographer as from 30-6-60.

Mr A. E. T. Ellawella—Junior Technical Assistant Grade II, (Low-country) as from 30-6-60.

Mr K. Sothisrihari—Junior Technical Assistant Grade II, (Technology) as from 5-8-60.

10. Other Business

(1) Junior Staff Provident Fund.—Reported that Mr R. I. Pereira had been elected to act as Trustee representing the Junior Staff on 9-8-60.

The report was received.

(2) Junior Staff Medical Fund.—Reported that Mr W. P. Chandrasekera had been elected to the Committee of Management as representative of the Junior Staff as from 9-8-60.

The report was received.

H. J. Balmond
Secretary

LETTER TO THE EDITOR

TROUGH WITHERING OF GREEN LEAF

I have recently been able to study trough-withering systems in East Africa, and my observations may be of interest to readers.

There are two types of trough-withering systems, namely:—

(*a*) suction/reversible type
(*b*) pressure type

Thanks to the generosity of the Rajawella Produce Co. Ltd., I have had every facility for studying, at first hand, both types of trough-withering systems on Changana and Mau Forest Estates, Kericho; Thornwood and Swazi Estates, Nysaland; Melosa, Milange and Liazi Estates, Portuguese East Africa; and Salama Estate, Uganda.

(*a*) Reversible suction type

This comprises a sealed rectangular chamber, at one end of which a fan draws air through openings placed at the other end. In passing across the chamber, the air is forced by means of trap-doors to pass through a horizontal bank of green leaf (about 8—10 inches thick) suspended at a convenient level above the ground, in a large drawer or trough perforated at the bottom. By adjusting the trap-doors, the air may be made to pass through the leaf in either an upwards or a downwards direction.

The air which enters the chamber is heated by means of steam radiators, or it may be ducted from the exhaust of tea driers in much the same way as warm air is now used from central bulking chambers.

(*b*) Pressure type

In this system the perforated drawer or trough is supported on a sealed chamber. At one end of the chamber, air is forced by means of a fan into the sealed chamber, and it is then allowed to escape upwards through the bank of leaf in the trough.

The incoming air is heated either by a heat exchanger unit or by steam radiators.

Advantages and Disadvantages of the two Systems

Reversible suction type

Advantages..—The main advantage claimed for this type of trough is that once the leaf is placed in the trough it requires no further handling until withering has been completed. In actual practice, however, this is not always the case, because, when the leaf is wet with surface moisture, "nesting" or sticking together of the leaves occurs, unless the bulk is turned from time to time.

One advantage of this reversible suction trough, however, is that it lends itself to being "tailor-made", and it is therefore suitable and easy to install in factories

which are unorthodox in size and shape. Furthermore, the chamber can be constructed on the estate, by the estate carpenter.

Disadvantages—Being a sealed chamber, it is only a matter of time before leaks occur which will effect the working of the trough. Being a sealed chamber, it is also difficult to supervise the work of loading and unloading the leaf as well as the half-hourly adjustments to the trap-doors which change the flow of air.

Pressure Troughs

Advantages.—The pressed-steel "Wilken" trough, which is covered by a patent, is quick and simple to install.

From the point of view of administration and factory management, the pressure troughs are completely open, and thus inspection of all the troughs becomes a very simple matter.

Although turning the leaf twice or thrice is recommended, there are no trap-doors to operate during the process of withering.

Disadvantages.—There are really no disadvantages which cannot be easily rectified. For instance, on Changana, exhausted air was being sucked back into the inlet because the trough had been incorrectly sited, but this will be a simple matter to correct.

In the "Wilken" trough, air may be heated by either an oil-fired heat exchanger or by steam heaters. These are the most expensive single items in the overall cost of the machine, and if they could be avoided by using exhaust air from the driers, this would make the pressure trough a most reasonably priced machine.

Common Faults in both Systems

The method of loading and unloading the leaf on to the troughs is tedious and highly inefficient in both systems. These are faults, however, which require only a little ingenuity to overcome. Certain modifications, which it is thought will increase the efficiency of these jobs, have already been suggested to the makers.

Operation

Technically speaking, the results obtained from both systems of trough withering are bound to be the same because the same fundamental principles are employed in each case. This applies to the depth of leaf, air volumes, and temperatures used as well.

I was most impressed by the uniform withers produced by both systems, as well as by the controllability of the withers which could be adjusted to within very small limits. One has no hesitation in saying that the best withers obtained by orthodox tat withering do not compare in evenness to trough withering.

On balance, therefore, and except in the exceptional circumstances mentioned above, the pressure system of trough withering has many advantages over the suction/reversible.

Application to Ceylon Conditions

Messrs Woods of Colchester Limited recently offered, free of all charge, two of their pressure troughs to the Tea Research Institute for experimental purposes, and the writer had much pleasure in thanking them on behalf of the Board of Control.

Nevertheless, from what I have already seen of trough withering, I am fully satisfied that this is the answer to the problem of dealing with heavy crops during the rush season.

Relative Capacities of Orthodox Withering Lofts and Troughs in terms of lbs. green leaf per square foot of floor area

Based on an orthodox Ceylon loft with 19 tats per bank at $4\frac{1}{2}$ inches spacing.

1 lb. G.L. to 15 sq. ft. of Tat	=	0.7 lb. G.L. per sq. ft. floor space
1 lb. G.L. to 10 „ „ „ „	=	1.0 „ „ „ „ „ „ „
1 lb. G.L. to 8 „ „ „ „	=	1.3 „ „ „ „ „ „ „
Pressure Trough	=	3.3 „ „ „ „ „ „ „

It will be seen, therefore, that by installing troughs in the loft in place of the normal tats, the capacity of the loft would be increased by 370% in the case of 1 lb. per 15 sq. ft. spreading, and approximately 230% in the case of 1 lb. per 10 sq. ft. spreading.

(Note: The size of a single "Wilken" trough is 60 ft. by 6 ft., and this will hold approximately 1500 lbs. green leaf. In practice, however, it is usual to install the troughs in pairs.)

From the above figures it should be a simple matter to calculate how many tatted lofts should be converted to troughs to cope with rush season crops.

C.F.I.A. Regulations

It is most unlikely that the C.F.I.A. will permit heat exchange units to be installed in the lofts. There should however be no difficulty in arranging for the troughs to be fed with hot air from the central bulking chamber, which would, as already mentioned, reduce the cost of troughs enormously.

Storage bins

This is a device for storing green leaf until such time as troughs are available for withering, and under African conditions two withers a day are the rule rather than the exception. These storage bins, however, are never likely to be used in Ceylon, and therefore require no further consideration.

Cost

At present, no details of costs are available for Ceylon. However, the costs given below have been kindly supplied by Mr W. S. S. Mackay, of Kericho, and whilst they refer to Changana factory, which troughwithers 1.5 million pounds made tea per annum, they are of interest in so far as they show the *relative* cost of orthodox, drum and trough withering systems.

	Capital Cost	Annual Running Costs	Relative Maintenance
Controlled Tat Withering ...	£60,000	£1,300	Negligible
Drums	£64,000	£5,500	Low
Troughs (Pressure).	£10,000	£5,325*	Low

The above refers to a crop of 1.5 million lbs. made tea per annum.

(*Note: Air is heated by heat exchange units. If warm air is ducted from central bulking chambers, as advocated, the annual running costs would be appreciably reduced.)

Length of Withers

In Africa, one hears planters talk of their three-hour and five-hour withers, in much the same way as in Ceylon one listens to planters talking of their 1,000 and 1,500 lbs.-per-acre yields.

By this it is not suggested that the introduction of troughs into Ceylon would automatically mean that the leaf would have to be manufactured after a three-hour or five-hour wither, because withers in Africa are very much lighter than those in Ceylon.

Whilst in Nyasaland, I had no difficulty in retarding what was normally a four-hour wither to twelve hours, and it would have been a simple matter to have extended it for a further four hours, thus bringing the length of withering time more into line with Ceylon conditions. It was also interesting to note that the teas from these extended withers were subsequently reported on highly in London.

Summing up, therefore, I am of the opinion that the use of pressure troughs for withering during the rush season in Ceylon is a highly feasible proposition, besides which their installation would save the cost of expensive factory extensions.

W. H. W. COULTAS

Venture Group,
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